LIVERPOOL SCHOOL OF TROPICAL MEDICINE

REPORT

OF THE

MALARIA EXPEDITION

TO

NIGERIA

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LIVERPOOL UNIVERSITY PRESS

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR III

REPORT

OF THE

MALARIA EXPEDITION TO NIGERIA

OF THE

LIVERPOOL SCHOOL OF TROPICAL MEDICINE AND MEDICAL PARASITOLOGY

BY

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PART I. MALARIAL FEVER, ETC.

WITH ILLUSTRATIONS AND PLANS

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TO THE

RIGHT HONOURABLE LORD LISTER, F.R.S., LL.D., D.C.L.,

THIS REPORT IS RESPECTFULLY DEDICATED

BY THE

LIVERPOOL SCHOOL OF TROPICAL MEDICINE

ISSUED BY THE COMMITTEE

OF THE

LIVERPOOL SCHOOL OF TROPICAL MEDICINE AND MEDICAL PARASITOLOGY

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Due acknowledgement must also be rendered for the help of the local agents of the African Association, Miller Bros. and Co.; Oil Rivers Trading and Exploration Company; and the Niger Company.

DIARY OF THE EXPEDITION'S MOVEMENTS

1900

March 21 Sailed from Liverpool per s.s. 'Olenda' (Captain HAMPSON).

April 11 Arrived at Old Calabar, Southern Nigeria.

May 3 One of the members started on a visit to Okoyong, Adiabo, and Ikoneto—a few miles up the Calabar and Cross Rivers—returned May 7.

„ 14 Two members visited Creek Town, on the Calabar River.

„ 17 Sailed for Bonny per s.s. 'Sokoto' (Captain WYNDHAM).

„ 18 Arrived at Bonny.

June 18 Two members started on a tour of 'the creeks.'
Arrived at Bakana (Slave Trees).

„ 20 Visited native town at Top Bakana.
Arrived at Bugama.

„ 21 Arrived at Degema.

„ 23 Visited Egwanga, up the Opobo River.

„ 24 Walked through the bush to Kwatown, four miles from Egwanga.

„ 25 Arrived at the Consulate, Opobo.

„ 26 Visited native town of Opobo.

„ 28 Returned to Bonny.

July 18 One of the members started for Okrika and Degema.

„ 22 Returned to Bonny.

Aug. 1 One of the members sailed for the Opobo River.

„ 2 Left Opobo and reached Akwete.

„ 5 Visited Obunko and Ohumbele.

„ 6 Reached Azumini.

„ 8 Returned to Akwete.

„ 9 Arrived at Bonny.

„ 10 Dr. ELLIOTT returned to Liverpool per s.s. 'Sokoto.'

„ 11 Drs. ANNETT and DUTTON proceed to Degema.

„ 13 Arrived at Akassa, by steam launch through the creeks.

„ 20 Visited Brass.

„ 21 Started for Agberi, on the River Niger.

„ 22 Arrived at Agberi.

„ 23 Reached Abo.

„ 24 Visited Utshi—reached Asaba.

„ 28 Visited Onitsha.

Sept. 4 Started for Lokoja.

„ 5 Passed Idah.

„ 6 Arrived at Lokoja.

1900

Sept. 13 Returned down stream by Niger Company's steam launch 'Nupe.'
„ 14 Arrived at Onitsha.
„ 20 Visited Abutshi.
„ 27 Sailed for Burutu.
„ 28 Arrived at Abo.
„ 30 Arrived at Ganagana.
„ 31 Arrived at Burutu.
Oct. 8 Sailed for Liverpool per s.s. 'Bornu' (Captain HELE).
„ 28 Arrived at Liverpool.

REPORT OF THE MALARIA EXPEDITION TO NIGERIA OF THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE AND MEDICAL PARASITOLOGY

I. PRELIMINARY

1.—*Introduction.* Scientific research and investigation in the subject of the aetiology of malarial fever during the last twenty years of the past century furnished results unequalled in their important bearing, not only in the science of parasitology, but more especially on the imperial question of the colonisation of the notoriously unhealthy parts of tropical and subtropical countries.

In 1880 Laveran,[1] in Algiers, first discovered adventitious living organisms in the red blood corpuscles of patients suffering from malarial fever, which were characterised by the possession of a dark pigment, and by their capability of executing amoeboid movements.

In 1889 Golgi,[2] of Pavia, by studying the 'rosace' forms, was able to differentiate between tertian and quartan forms of fever, and to trace out the processes of maturation and sporulation of the parasites and their relations to the periodicity of these fevers.

In 1894, Manson[3] originated the idea that the malarial parasite was capable of an existence outside the human body, in which the 'flagellate' form played an important rôle. He was led to suggest that the mosquito served as a host for the further development of the parasite.

Ross, in 1897[4] and succeeding years,[5] established the truth of these ideas, and first succeeded in the cultivation of the crescent form of the aestivo-autumnal parasite (*Haemomenas praecox*) in the stomach of *Anopheles rossii*. In 1898 the life-history of a similar parasite of birds (*Proteosoma grassii*, *Haemamoeba relicta*) was worked out by him—from the formation of zygotes from the fertilised female parasite (*macrogamete*) in the stomach wall of *Culex pipiens* to the collection of the germinal rods (blasts, sporozoïtes) in the cells of the salivary glands. The complete biological cycle of the parasite was furnished by the production of infection in healthy birds by the bites of mosquitoes previously fed on infected birds. Confirmation of these

researches, both in general bearing and in detail, has been afforded by the observation of the fertilisation process in the case of halteridum of birds (*Haemamoeba danilewskii*), as well as of human aestivo-autumnal parasites (*Haemomenas praecox*) by MacCallum,[6] and further of the formation of the 'vermicule' in the case of proteosoma of birds (*H. relicta*), by Koch,[7] and in the case of human malaria by Grassi,[8] who also observed by histological processes the passage of the 'vermicule' through the epithelial lining of the stomach of the mosquito.

The Italian pathologists and zoologists, Bastianelli and Bignami,[9] Celli[10] and Grassi,[11] and others having peculiar facilities and opportunities for research in the subject in Italy, have contributed many confirmatory articles, and also by considerable experimental work have brought forward evidence which exculpates mosquitoes of the genus *Culex* from any part in the transmission of human malarial fever.

The interesting experiment of Manson and Thorburn,[12] who, in London last year, allowed themselves to be bitten by mosquitoes infected from a case of tertian fever in Italy, and after fourteen days acquired a typical attack, exhibiting tertian parasites in the blood, afforded a strikingly conclusive confirmation of the work of Ross and of Italian observers.

These discoveries naturally opened up the question as to how the results obtained might be turned to practical account for the prevention of malarial fever, so that commissions and expeditions were despatched to the tropics to ascertain at what period of the life-history of the parasite in man and in the mosquito the parasite is the most vulnerable, and how the attack might best be delivered.

In 1899 there were sent out a German Commission under Professor Koch in German East Africa, a Royal Society's Commission to British Central Africa, and the expedition to West Africa from the Liverpool School of Tropical Medicine under Major Ross. In 1900, another German Commission, under Professor Koch, was despatched to the East Indies ; the Royal Society's Commission visited West Africa, and a second expedition from the Liverpool School of Tropical Medicine was sent to West Africa.

Objects of the Expedition.—The experience of Major Ross in India, and the consideration of the results of his work, led to the conclusion that the parasite could be most easily attacked during its life in the mosquito, and as there was considerable evidence to exclude mosquitoes of the genus *Culex* from taking any part in the transmission of malarial fever, the first expedition of the Liverpool School of Tropical Medicine, of which one of us was a member, was undertaken to study the bionomics of mosquitoes of the genus *Anopheles*, with a view to suggesting better modes of prevention of malarial fever than those hitherto known to us.[13] As to the conclusions arrived at and the methods suggested, these will be found fully described in the report of the expedition.[14]

The objects of the present expedition were as follows :—

(1) To further explore West Africa to ascertain under what varied conditions mosquitoes of the genus *Anopheles* lived and propagated, with a view of ascertaining the most feasible and practical methods of preventing malarial fever.

(2) To investigate the conditions under which malarial fever is conveyed to Europeans.

(3) To corroborate and extend recent discoveries and researches on the subject.

It was not intended to limit observations to malarial fever alone, but to study also other tropical diseases as opportunity arose, and to note in addition the general sanitary condition of the places visited.

History of the Expedition.—Nigeria, Northern and Southern, were chosen for the field of operations.

The expedition consisted of :—

H. E. Annett, M.D., D.P.H. (Vict.), Demonstrator in Tropical Pathology, Liverpool School of Tropical Medicine.

J. Everett Dutton, M.B., B.Ch. (Vict.)

J. H. Elliott, M.D. (Toronto).

The proceedings of the members of the expedition during the seven months in West Africa are given in the diary of the expedition's movements. The first five weeks were spent at Old Calabar, but the work of the expedition here was almost fruitless, because of the condition of the natives, who are a dull, unintelligent people, understanding almost no English. For the next three months, Bonny, a very old and well-known trading station, was made headquarters, and here most of the work of the expedition was done. Accommodation was spacious, and intercourse with the natives was easy ; English is spoken, and civilisation fairly advanced. Numerous experiments and researches were carried on here, and in view of what the later experience of the expedition proved, it was unfortunate that a longer stay was not made. From the time of leaving Bonny, the work of the expedition became more or less exploratory only. The Niger district of Southern Nigeria having only recently been taken over by the Government, the expedition found at all the places on the Niger and its delta which were visited, accommodation so scanty as to render scientific investigation impossible, in fact, in some places actual living was rough and uncomfortable. In Northern Nigeria, Lokoja alone was visited, and here, again, the accommodation which was available rendered a longer stay than a few days impossible.

II. TOPOGRAPHY AND STATISTICS

Roughly, Nigeria may be divided in its topographical characters into three regions—the region of mangrove swamp, with but little vegetation beyond the mangrove tree, lining the coast and reaching inland to an extent varying from a few to a hundred miles; studded here and there with the low-lying, dirty, swampy towns and villages of the African negroes. Beyond this is the thickly-forested belt—the palm oil region—with much cleaner and often well-arranged towns; and natives engaged chiefly in agricultural pursuits. Further inland is the deforested tract extending to the edges of the central desert. This country is hilly and undulating, and covered with a short scrub and but few trees, and is chiefly occupied by tribes professing Mohammedism. Here and there the depressing monotony of the extent of mangrove swamp is relieved along the course of the rivers or the streams forming the delta, by the occurrence of patches of thickly forested land of small area—anticipating the character of the forested belt further inland.

Old Calabar, the chief town of Southern Nigeria and the seat of government administration, is situated about fifty miles up the Old Calabar river, on its left bank. The river up to here is lined with mangrove swamps and studded with islands of mangroves. The town is placed on the edge of the forested plateau which lies beyond the region of swamp. The mangrove region extends on the opposite bank still some miles further inland. The plateau is about two hundred feet high, where it here comes to the river; it terminates rather abruptly, and slopes rapidly to the water's edge. Old Calabar is built on this slope. Two short spurs jut out, so that the town is surrounded in a semi-circular fashion by the edge of the plateau. On the western half of the slope is the native town of Duketown, which is continued over the summit of the spur into the small village of Henshawtown. A creek, some swampy district, and a small valley separate this native half from what may be called the European half of the town. The European quarters are built mostly on the edge of the eastern half of the plateau; government offices and other administrative premises are dotted about on the slope below. Over the easterly spur is the small village of Oldtown, and Quatown is another small village about one-half to one mile inland on the level plateau. The factories of the various trading companies are dotted about on the water's edge from the extreme end of the native town to the end of the European half.

Proceeding up the hill on the European side of the creek from the Queen's beach and the offices of the marine department, are met with, first the customs and post-offices, and the public works department offices about half way up the hill;

THE NATIVE TOWN OF DUKITOWN—OLD CALABAR

ON THE EXTREME RIGHT AND LEFT ARE TWO EUROPEAN FACTORIES, ALMOST SURROUNDED BY NATIVE HUTS. TO THE RIGHT OF THE FACTORY, JUST SHOWING ON THE EXTREME LEFT, IS THE 'CREEK.'

then nearer the top is the Vice-consulate, and on the summit are the Consulate and Medical house. Further round are the Force house and barracks of the West African Frontier Force, the prison, the European hospital, and a Presbyterian mission station.

On the edge of the creek also on the European side of it are built the native hospital and the dwellings of native clerks, court messengers, and orderlies. It is not permitted that native houses should be built on this side of the creek, thus procuring a distance of about half a mile between the government European quarters and the native town. The few native huts which have existed there for a long time before the present European quarters were built are being gradually removed.

The vicinity of these quarters has been excellently laid out, and is kept in remarkably good order. Excellent roads, well ditched with cemented gutters, cross the hill in all directions ; the quarters are fairly well designed. The total European community at Old Calabar numbers about one hundred and twenty.

Duketown presents a marked contrast to the European half of the town. Here the native huts are crowded together, although some efforts have been made by the medical and public works officers of the district to construct wide roads and to improve the sanitary condition of the town. Narrow winding and irregularly made paths run down the hill side between the native huts which, reaching down to the beach, are crowded round the factories of the trading companies there. On the whole, however, the huts, which are of clay, are fairly clean, although the Calabar native is unintelligent, lazy, and but little influenced as yet by civilisation. Another mission station is built near the summit of this hill, surrounded by native houses.

Throughout the native town and villages on the river's edge numerous dug-out canoes, drawn up to the neighbourhood of the native huts, formed the principal breeding-places of *Anopheles* — and here and there a 'puddle' in the clay at the sides of the paths contained larvae. On the edges of the 'creek,' besides innumerable canoes, several small puddles in this swampy district were found to contain larvae also.

A narrow footpath runs along the whole length of the beach behind the trading factories, and from one factory to the next. This is badly constructed, and permits of the formation of shallow pools during the rains — we observed these several times with innumerable *Anopheles* larvae. The proximity of the native huts to the factories, and the presence of many breeding-places of *Anopheles* in their immediate vicinity, explain the prevalence of malarial fever among the Europeans here, who, moreover, from the low position of the factories on the water's edge and from the general contour of the district, are denied the enjoyment of those refreshing breezes which is secured by the Europeans in the more favourable position on the hill.

Near the quarters of the Government officials on the hill no breeding-places of *Anopheles* could be found during the period of our visit, except a small 'duck'

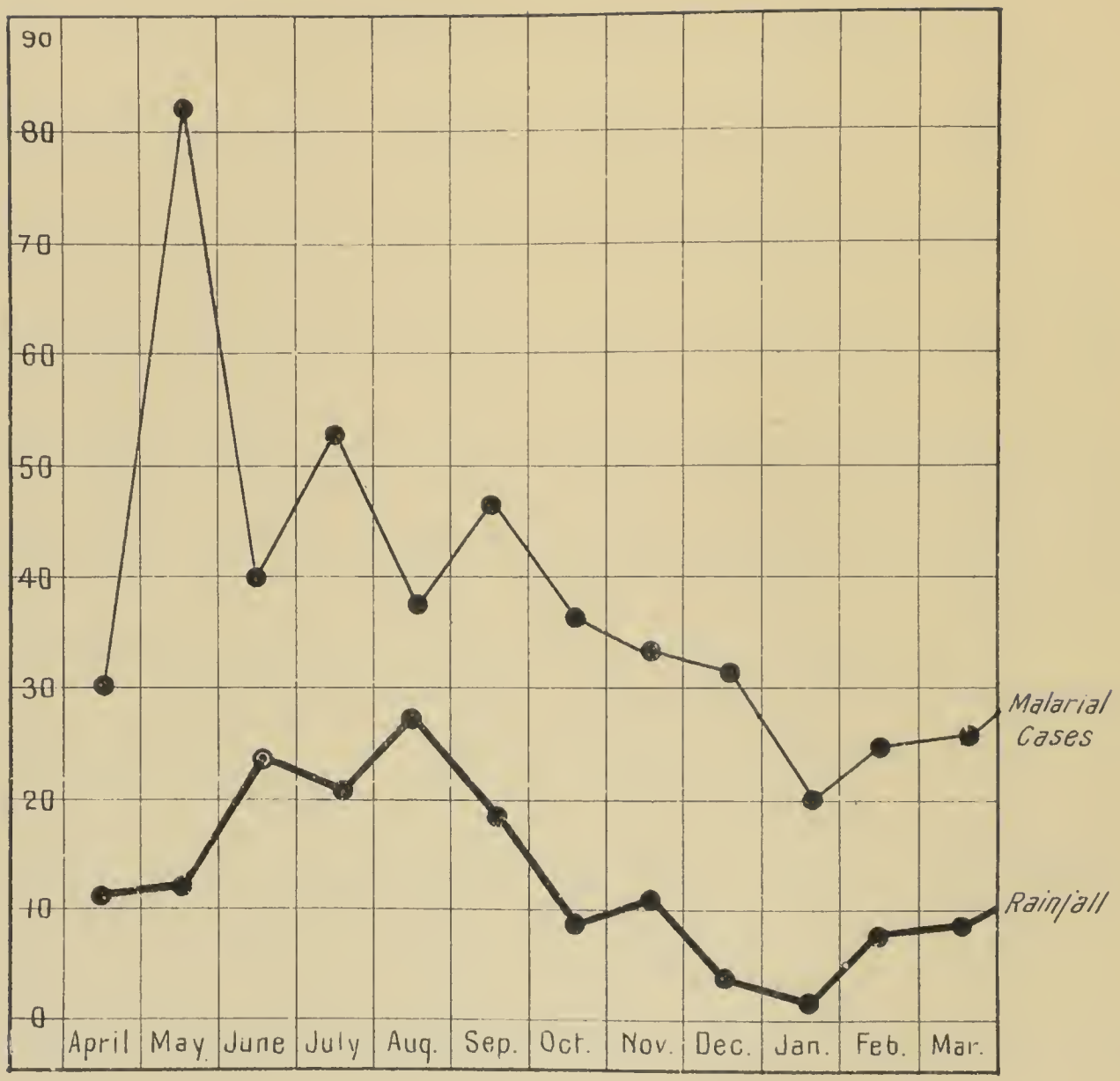
pond near the consulate. The water of this cemented pond was so often disturbed by fowls, turkeys, and other poultry, that never more than very few larvae were found here. Since our visit it has been regularly emptied.

The water supply of the natives is a spring in the valley above the 'creek'—that of Europeans is rainwater caught from the roofs of their quarters, and stored in large iron tanks. A scheme is on foot, however, to bring water to the town from a spring about two miles distant, in the bush, and engineering operations are at present being carried out. The spring occurs at the bottom of what appears to be a natural depression some one hundred feet deep. A well has been already bricked out here to the depth of some eight feet, and the neighbourhood of this was at the time of our visit flooded over a small area around. Here innumerable larvae were found. The district is visited by many natives for drinking water, and a number of labourers are employed during the day in the structural operations. These and the occupants of a small hut on the edge of the depression are the only people within half a mile of the place. The presence of such a large number of *Anopheles* larvae was therefore remarkable.

Of the other places in Southern Nigeria visited by the members of the expedition but little description need be here given—they will be sufficiently referred to in subsequent chapters. The European communities at these places seldom exceed ten in number.

Akassa must, however, be particularly referred to as a place which, in our opinion, should be at once abandoned by Europeans. A vice-consulate and the engineers' quarters are the only European habitations here, and these have been built on 'made' sites in the midst of the mangrove swamp. Here are the only engineering yards of the country, which were taken over from the Niger Company by the Government at the beginning of last year. Were not the swampy nature of the district sufficient reason for abandoning the place, it has been rendered almost uninhabitable because of the prevalence of malarial fever among the Europeans—brought about by the presence of the small native village on one side and of the dwellings of the native artisans and labourers with their families on the other side of the engineering quarters, while the proximity of the barracks of the native soldiers is a perpetual menace to the health of the officials at the vice-consulate. To abandon this place and to transfer administrative quarters and engineering yards to Brass, a comparatively healthy district some twenty-five miles off, where already an excellent vice-consulate building exists, would, in our opinion, involve the expenditure of a much less sum than will be required to make Akassa inhabitable and at all healthy.

Statistics.—It is very desirable that fuller and more detailed accounts of the meteorological conditions occurring at the various stations of Nigeria should be kept: at present there is a deplorable dearth of instruments for these purposes throughout the colony. It is only with considerable difficulty that we have been able to gather



It is to be noted how closely the number of Cases of Malarial fever among Europeans, follow the variations in the rainfall, and especially how the largest number of cases occur at the time when the rainy season has become fairly established.

details for the construction of the following tables and charts illustrating the relation between the amount of rainfall and the prevalence of malarial fever.

For an estimation of the rainfall we have found it necessary to take the average fall of three stations in the colony, and for the number of cases of malarial fever we were not able to obtain the reports of all the stations.

The following table gives the average rainfall per month of three stations in Southern Nigeria (one of which is Old Calabar) and the total number of cases reported as malarial fever among Europeans. It is necessary to point out that a few of the cases among Europeans were probably not truly malarial in character.

	Average Rainfall	Total Number of European Cases
1899—April	10·46	30
„ May	11·71	83
„ June	24·77	40
„ July	21·13	54
„ August	27·09	38
„ September	19·65	47
„ October...	9·08	37
„ November	10·40	33
„ December	4·58	31
1900—January	2·68	20
„ February	8·63	25
„ March	9·43	26

(Chart I)

It is to be noted how closely the number of cases of malarial fever among Europeans follows the variations in the rainfall, and especially how the largest number of cases occur at the time when the rainy season has become fairly established. Allowing for the period of the life history of the malarial parasite in the mosquito, and for an incubation period of the disease in man of from seven to twenty days, the relation of cases to rainfall is such as would have been anticipated from a consideration of the nature of the breeding places of *Anopheles* in the districts considered.

Lokoja is the most important town of Northern Nigeria. It is situated at the confluence of the Niger and Benue rivers, at a distance of about four hundred miles from the sea coast. Behind the town is a hill—Mount Patti—reaching about one thousand feet in height, and running almost parallel to the direction of the river bank. The hill slopes steeply down for a distance of about seven hundred feet, from which point the slope is less steep and takes the form of four low ridges with intervening vales running at right angles to the river bank. The most southerly of these ridges is called the 'hospital hill'—on which are built the European hospital, the quarters of the medical officers and of nurses and dressers.

The next is the 'barracks' hill with the bungalows of the officers of the First West African Frontier Force. The third may be called the 'Residency' hill, having the quarters of the government resident, the post office, and behind these the houses of a number of native clerks and other government employés. On the fourth hill and on the area beyond between Mount Patti, which here approaches nearer to the river, and the bank is the native town.

A road about three miles in length starts from the neighbourhood of the hospital, and, crossing the barracks and residency hills, enters the native town. On each side of this road, as it passes down the side of the hospital hill and up the barracks hill, are grouped the huts of the native soldiers, not very far distant from the bungalows of the Europeans officers. Several other native houses are dotted about near these bungalows.

In each of the valleys between the hills runs one or more small hill streams.

Between the residency and the river, on the sides of the road already mentioned, a bank and other European quarters are in course of construction.

On the water's edge and completely surrounded on one side and at the back with native huts, which reach up almost to the very boundary rail of the compound, is the factory of the Niger Company. Here there are usually some ten or twelve Europeans employed, while at the barracks live often as many as thirty.

Soldier Town is the name given to the district near the river at the base of the ridge known as 'hospital hill,' which is occupied by the greater number of the soldiers of the force with their families.

It is not difficult when one considers the manner in which the dwellings of Europeans are everywhere surrounded by those of natives at Lokoja, to understand how the town has gained for itself a reputation of unhealthiness, and more particularly the barracks of the West African Frontier Force, which might with very little trouble be made quite healthy.

The European quarters have throughout the town been allowed to become encroached upon by the native huts. As already mentioned, the Niger Company's factory has native houses close to its boundary rails : the bungalows of the officers have a collection of soldiers' huts, and a few other scattered huts not very

PORTION OF THE BARRACK SQUARE AT LOKOJA, SHOWING A EUROPEAN OFFICER'S BUNGALOW, AND TWO OR THREE NATIVE HUTS CLOSE BY. TO THE RIGHT IS A STACK OF ANT-PROOF PILES, SIMILAR TO THOSE ON WHICH THE BUNGALOWS ARE BUILT. THEY ARE PARTIALLY OVERGROWN WITH GRASS.
THE TRAPS CONTAIN WATER WITH MANY *Anopheles* LARVAE

far distant from them, while behind the residency are the houses of native clerks. In all these cases it would not be difficult, considering the ease with which native huts can be pulled down and re-built, to remove this dangerous condition.

Moreover, the neighbourhood of the European quarters provided many places for the breeding of *Anopheles*. In the barracks square an interesting condition was met with. The bungalows are supported on ant-proof piles, that is, piles provided with a cup to contain water. In these cups when they happened to have water in them were found *Culex* larvae in great numbers. About the centre of the square was a collection of such piles which, not having been moved for some time, were partly overgrown and hidden by long grass. The cups of these piles were found to contain *Anopheles* larvae. This illustrates the peculiar habits of the *Anopheles*, for though in this undisturbed position they were numerous, in similar cups under the bungalows none could be found. The whole surroundings afforded a beautiful example, shewing the source of infection (there were several native huts scattered about close by), and the means by which the infection was easily carried by *Anopheles* bred close at hand, to the Europeans in their bungalows.

A similar example was also provided by the conditions around the factory of the Niger Company. Between the factory boundary and the native huts we discovered a typical *Anopheles* pool containing numerous larvae. The pool was a portion of a very badly constructed drain which ran through the factory's area, which in its course also afforded several other breeding-places.

Besides these, there were many other breeding places of *Anopheles*. In a subsequent chapter it will be pointed out that the construction of roads and footpaths as carried out in many parts of West Africa provides numerous such breeding places. Such occurred on a large scale at Lokoja. The road already mentioned and other roads off this were found by us so badly ditched on each side, that instead of serving to quickly remove water, they permitted of the formation of a long string of puddles on each side, containing numerous *Anopheles* larvae. In some places, in spite of the fact that there is a good natural slope down the hillsides, the bed of the ditch formed a series of steps, water lodging on each. One road in particular is to be mentioned. It runs down the 'hospital' side of the 'barracks' hill. On each side are huts of native soldiers, at the top the officers' bungalows. This road was reconstructed during our visit to Lokoja, and after the work its condition was as bad as before. These samples serve to illustrate how the unhealthy condition of a European settlement is brought about often by the Europeans themselves, by permitting the natives to settle beside them, and further by the unwitting neglect of elementary sanitary and engineering principles.

Parts of the small hill-streams already referred to as running in the shallow valleys also provided *Anopheles* breeding places. These streams become torrents during heavy rain, quickly washing out any larvae ; but, during gentle rains, parts of

them, where they swell out into shallow pools with sluggish stream, form excellent breeding-places, and probably in the dry season, when they almost dry up, the pools last remaining perform a similar function. By wading along the course of some of these streams we are able to locate the breeding-places of *Anopheles* which they provided, always at a distance not exceeding two or three hundred yards from human habitations. Beyond this distance above the district of huts and bungalows we found no larvae.

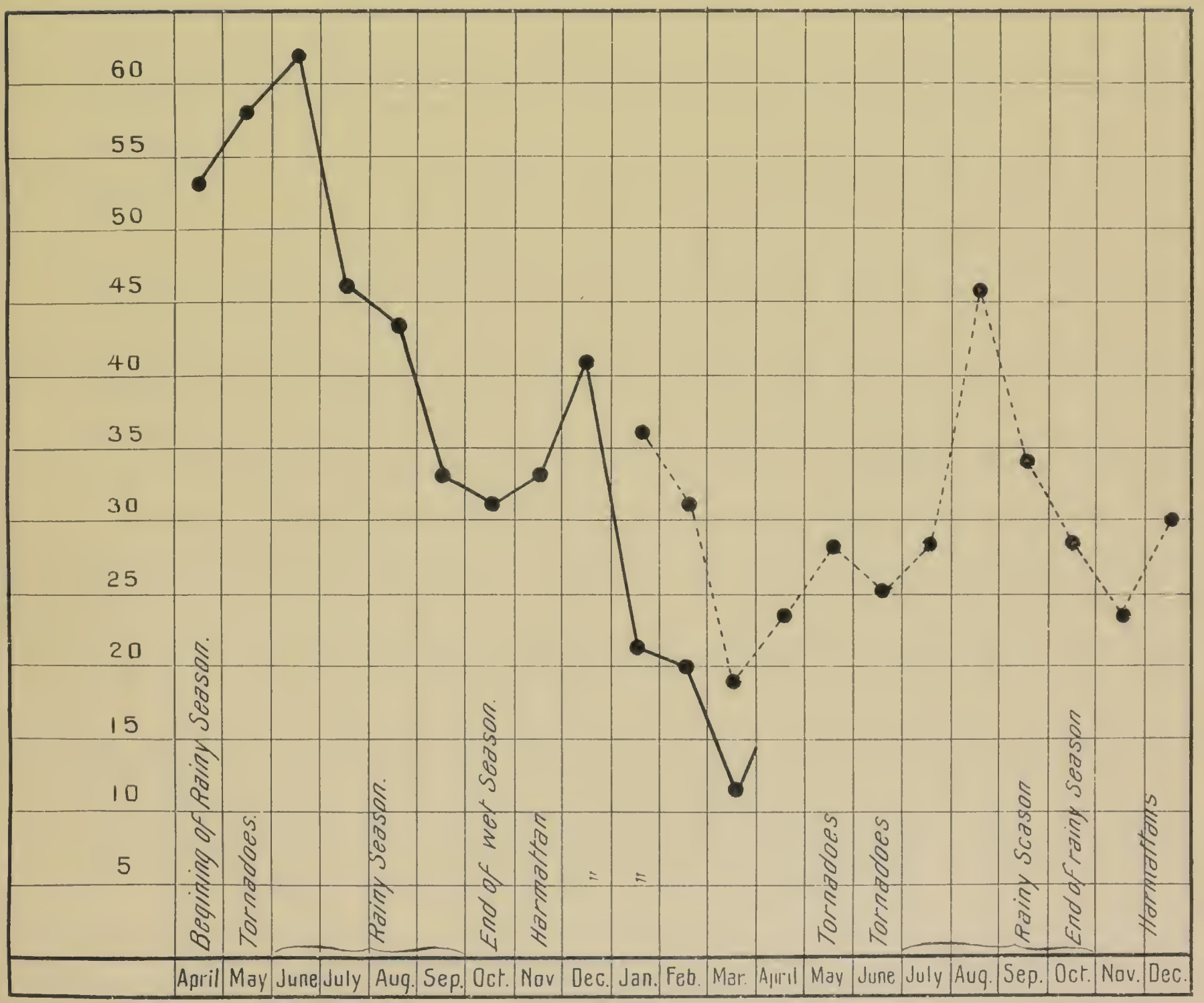
Still another condition was observed at Lokoja. At a point near the river bank we found a small area of cultivated land. We were unable to ascertain precisely the nature of the produce, but it was probably rice. The surface was dug so as to form rows of butts and furrows. One portion of the area was swampy, and water puddles were formed for a short distance along many of the furrows, and also along a narrow footpath crossing the field. In many of these puddles *Anopheles* larvae were found. Habitations in the immediate neighbourhood were scarce, but at a distance of two hundred yards was a collection of native huts.

Statistics.—Northern Nigeria.—The only statistics available are those given in the reports of the medical officers of the West African Frontier Force.

(Chart II)

The points of the line curve represent the percentages per month of the total European force admitted into hospital. Those of the dotted curve shew the actual number of cases admitted per month. Both curves shew a marked increase in the number of cases of malarial fever after the beginning of the rainy season, and the former also a smaller increase after the cessation of the rains. During the course of the wet season itself the breeding-places of *Anopheles* would be continually flooded out, but during its onset and cessation the insects would be able to breed continuously.

The following table has been constructed from the reports of Dr Wordsorth Poole, Principal Medical Officer, W.A.F.F. from January 1898, to March 31st, 1899, and of Dr McDowell, Acting Principal Medical Officer, for the year ending December 31st, 1899.



III. HAEMAMOEBIDAE IN NIGERIA

The Haemamoebidae in Definitive Hosts.—The nature of the expedition and its objects did not permit of a very extensive and minute investigation into the question of the proportion of mosquitoes infected, and the nature of the infection in the numerous places visited. During our three months' stay at Bonny, however, a number of mosquitoes comprising both *Anopheles costalis* and *A. funestus* were dissected and examined microscopically. These were obtained from huts in the native town, as well as from the European quarters of the two factories at Bonny and their outhouses. A total number of two hundred and eighty-one *Anopheles* were dissected, and seven only found to be infected. Roughly, much less than half of these were obtained from the native town, and since, in the light of later observations, it is very probable that the infected insects came from the native town, it can be roughly estimated that, whereas of the total only 2·6 per cent. showed infection, considering the dilution by mosquitoes from the neighbourhood of the factories where no native children dwelt, the percentage of infected mosquitoes in the native town probably exceeded six.

The nature of the infection in the seven *Anopheles* was as follows :—The exact type of parasite—tertian, quartan, or aestivo-autumnal—was difficult to decide.

(1) One mature zygote, showing typical arrangement of zygotoblasts.
(2) One large zygote, showing a few granules of fine pigment.
(3) One mature zygote, with zygotoblasts.
(4) One zygote about half developed.
(5) One zygote about five days old.
(6) Two large zygotes, not quite mature, containing few pigment granules. Salivary glands infected.
(7) Two small zygotes with pigment.

The great rarity with which 'gametes' of any type are met with in the blood of Europeans in West Africa, and the utmost difficulty experienced in work among native children, rendered any experiments requiring the feeding of mosquitoes on infected subjects, which it had been our intention to pursue, impossible during the comparative short stays we were able to make at different stations. Such investigations would require a long stay at one place.

Haemamoebidae in Intermediary Hosts.—The most striking result of the recent scientific expeditions to tropical countries for the study of the aetiology of malarial

fever is the discovery, first by Professor Koch, the director of the German Malaria Expedition, that the native children of tropical towns and villages are infected to an enormous extent with the parasites of malarial fever, and that they probably constitute the only source from which the disease is conveyed, by the agency of mosquitoes of the genus *Anopheles*, to Europeans. This has been corroborated by the members of the Royal Society's Commission in West Africa, and also by us. Professor Koch's reports[1] show that he found malarial parasites in the blood of a proportion of the native children under two years of age, to the extent, in some places, of 100 per cent.; of children between two and five, up to 46·1 per cent.; and between five and ten, up to 23·5 per cent. were infected; while in natives over ten, none were found to contain parasites. The proportions obtained by the Royal Society's Commission in West Africa, who also discovered the infection of native children independently, are somewhat higher than these; at Accra[2], from 23 to 90 per cent. of 'babies'; from 20 to 57 per cent. of children up to eight years; from 28 to 30 per cent. up to twelve years; and over that age infection was rare; while at Lagos, of children under two years, from 50 to 100 per cent.; between two and five years, 40 to 75 per cent.; and between five and ten years, 25 per cent. showed either parasites or pigmented leucocytes in their blood, the percentage varying according to the locality.

We were able at almost every town we visited to obtain a number of children for examination. The following tables show our results:—Our method of examination consisted in making a blood smear of about two inches in length and half an inch in breadth. After drying and fixing in absolute alcohol, the preparation was stained by a modification of Romanowsky's method for 'chromatin' staining, and the whole smear carefully examined with a one-twelfth oil immersion objective (Zeiss). The presence of pigmented leucocytes was not specially recorded in the results, the presence of parasites alone serving as the index of infection. The number of parasites found varied from two or three per whole smear up to a large number in every field of the microscope. The ages of the children are given as nearly as could be judged from a general glance. It is possible that in some cases they may be one or two years out. Of those over ten years the majority were from ten to fourteen; only very few between fourteen and eighteen were examined. The different places at which examinations were possible are as follows:—

(*A*) *Bonny Town.*—The native town is close to the Government Vice-consulate and European factories. Many of the specimens were obtained by a house to house visitation indiscriminately, others by visits to huts belonging to one or two Bonny chiefs.

(*B*) *Herbert Jumbo's Plantation.*—This is some five miles up the river from Bonny Town. Here lives the chief, Herbert Jumbo, in the midst of his men and boys and their families, previously 'slaves.'

(*C*) *Ju-Ju Town, Bonny.*—This is the name given to another plantation nearer the mouth of the river, belonging to Chief William Brown. The conditions here are similar to those above described. There are no Europeans in the district.

(*D*) *Akwete Town.*—There are no European traders here, but a Consular Court necessitates the continual presence of one or two Government officials.

(*E*) *Egwanga Town.*—The specimens were taken from children of a small native village, which practically surrounds the traders' factories here.

(*F*) *Onitsha.*—The children who furnished specimens came to the dispensary of the Church of England Missionary Society's station here, or to the school belonging to the same Society.

(*G*) *Akassa.*—Some specimens were obtained from the children of the Hausa soldiers here, who lived in huts in close proximity to the Vice-consulate ; others from children of native engineers, etc., employed in the engineering yard. In the midst of them live three or four Europeans in the Government service.

(*H*) *Asaba.*—The only children obtainable were those of the Hausa soldiers, one or two companies being stationed here.

(*I*) *Lokoja Town.*—The nominal King of Lokoja could prevail upon only very few of his people to provide us with specimens.

(*J*) Others were obtained from the barracks of the Hausa soldiers at Lokoja. The Yoruba soldiers refused absolutely.

	A. Bonny Town			B. Plantation		
Ages	No. Examined	No. Infected	Percentage	No. Examined	No. Infected	Percentage
0-1	6	0	...	2	0	...
1-2	6	4	...	7	2	...
2-3	7	3	...	4	2	...
3-4	16	9	...	6	4	...
4-5	7	2	...	6	3	...
5-6	3	0	...	2	1	...
6-7	4	0	...	4	1	...
7-8	3	2	...	2	1	...
8-9	2	0	...	6	2	...
9-10	1	0	...	1	0	...
10+	12	1	...	18	1	...
0-5	42	18	42·8	25	11	44·0
5-10	13	2	15·3	15	5	33·3
10+	12	1	8·3	18	1	5·5
Total...	67	21	31·3	58	17	29·3

	C. Ju-Ju Town			D. Akwete		
Ages	No. Examined	No. Infected	Percentage	No. Examined	No. Infected	Percentage
0-1	1	0	...	10	1	...
1-2	11	8	...	4	2	...
2-3	12	8	...	8	3	...
3-4	9	5	...	3	1	...
4-5	12	7	...	4	2	...
5-6	4	0	...	4	1	...
6-7	10	1	...	2	0	...
7-8	9	4	...	5	1	...
8-9	2	1	...	1	0	...
9-10	1	0	...	5	0	...
10+	1	0	...	2	0	...
0-5	45	28	23·0	29	9	31·0
5-10	26	6	62·2	17	2	11·7
10+	1	0	...	2	0	...
Total...	72	34	47·2	48	11	22·9

	E. Egwanga			F. Onitsha		
Ages	No. Examined	No. Infected	Percentage	No. Examined	No. Infected	Percentage
0-1	3	1	...	0	...	...
1-2	4	3	...	4	2	...
2-3	8	7	...	2	2	...
3-4	3	2	...	5	1	...
4-5	2	1	...	4	1	...
5-6	2	1	...	4	2	...
6-7	2	0	...	5	0	...
7-8	0	...	...	2	1	...
8-9	1	1	...	1	0	...
9-10	0	...	...	2	0	...
10+	0	...	...	0	...	...
0-5	20	14	70·0	15	6	40·0
5-10	5	2	40·0	14	3	31·0
10+	0	...	...	0	...	...
Total...	25	16	64·0	29	9	21·4

	G. Akassa			H. Asaba		
Ages	No. Examined	No. Infected	Percentage.	No. Examined	No. Infected	Percentage
0-1	3	1	...	5	3	...
1-2	2	0	...	1	1	...
2-3	1	1	...	2	2	...
3-4	1	0	...	3	2	...
4-5	0	...	...	2	2	...
5-6	2	2	...	0	...	...
6-7	1	0	...	2	0	...
7-8	2	1	...	1	0	...
8-9	0	...	...	2	0	...
9-10	0	...	...	2	2	...
10+	0	...	...	0	...	...
0-5	7	2	28.5	13	10	76.9
5-10	5	3	60.0	7	2	28.5
10+	0	...	...	0	...	...
Total...	12	5	41·6	20	12	60.0

	I. Lokoja Town			J. Lokoja Soldiers		
Ages	No. Examined	No. Infected	Percentage	No. Examined	No. Infected	Percentage
0-1	0	...	...	7	4	...
1-2	1	1	...	6	6	...
2-3	1	0	...	4	3	...
3-4	0	...	...	1	0	...
4-5	2	1	...	2	1	...
5-6	1	1	...	1	0	...
6-7	0	...	...	0	...	...
7-8	1	1	...	0	...	...
8-9	1	0	...	0	...	...
9-10	2	0	...	0	...	...
10+	7	2	...	0	...	...
0-5	4	2	50·0	20	14	70·0
5-10	5	2	40·0	1	0	...
10+	7	2	28·5	0	...	...
Total...	16	6	37·5	21	14	66·6

These tables show that the number of infected children varies from place to place from 22·9 to 66·6 per cent. ; that over ten years of age very few are infected ; that children between 0 and five years are infected to a great extent.

The following table shows the total numbers and percentage of children infected at different ages throughout the whole country traversed by the expedition.

TABLE SHEWING THE TOTAL NUMBER OF CHILDREN EXAMINED AND INFECTED THROUGHOUT NIGERIA

Ages	No. Examined	No. Infected	Percentage Infected
0-1	37	10	27·3
1-2	46	29	63·0
2-3	49	31	63·0
3-4	47	24	51·0
4-5	41	20	48·8
5-6	23	8	34·8
6-7	30	2	6·6
7-8	25	11	27·5
8-9	16	4	25·0
9-10	14	2	14·2
10+	40	4	10·0
0-5	220	114	51·8
5-10	108	27	25·0
10+	40	4	10·0
Total...	363	145	39·9

By plotting down to scale the figures of the last table, with ages as abscissae, and percentages of children infected as ordinates, a curve is obtained shewing the relation of age to infection. This demonstrates that the number infected is greatest between the ages one and three, and is large also up to five years. The curve shows a very decided fall in the sixth year, after which there is a slight rise, and a rapid fall again during the ninth and tenth years. As to the reasons for the fall in the sixth year, nothing can be given—it may be only accidental.

(Chart III)

The curve also shews how immunity from malarial fever is acquired among the natives. There is besides a certain inherited immunity, since it is well-known that the children of Europeans are severely, and often fatally, attacked by the disease in the tropics, while the native children seem to be but little affected. A temperature of 103° F. was once noted in a child of six months, and occasionally small children in arms were met who evidently were sick and had temperatures—but beyond these, most of the children seem to suffer but little inconvenience, although an examination of their blood at the time might reveal numerous parasites in every field of the microscope. Immunity appears to be more or less completely established by the time the age of ten years is reached, in some cases, however, a longer period appears necessary.

This acquired immunity lasts for a considerable number of years, in many cases a life-time—the period really depending on the extent and frequency of infection during childhood and on individual idiocyncrasy. It has been observed that in all the places visited by us a proportion of the native children were infected, and that the proportion varied and, therefore, the chances of exposure to infection varied. It is possible that there exist in West Africa towns and villages where no malarial fever exists—the natives of such places on entering a malarious district would suffer almost as severely as Europeans. It was only occasionally that we met a native adult complaining of fever, and then only slight inconvenience was occasioned by the attack, which seldom lasted more than twenty-four hours. The returns of the Principal Medical Officer for Southern Nigeria shew a number of adult natives treated, entered as suffering from malarial fever. As microscopical examination was but very little used as a means of diagnosis, it is probable that, although some of these cases may have been true malarial fever, others are, no doubt, fevers of a different nature. In two cases of adults suffering from fever, examined by us, ring forms were found in fair number.

The actual extent and nature of the infection in individual cases at the time of examination are given below.

It will be seen that aestivo-autumnal, quartan, and tertian parasites were found, and, at the time of our visit, the majority of the cases were aestivo-autumnal, while there were also a number of quartan cases, and only a few tertian. Probably the

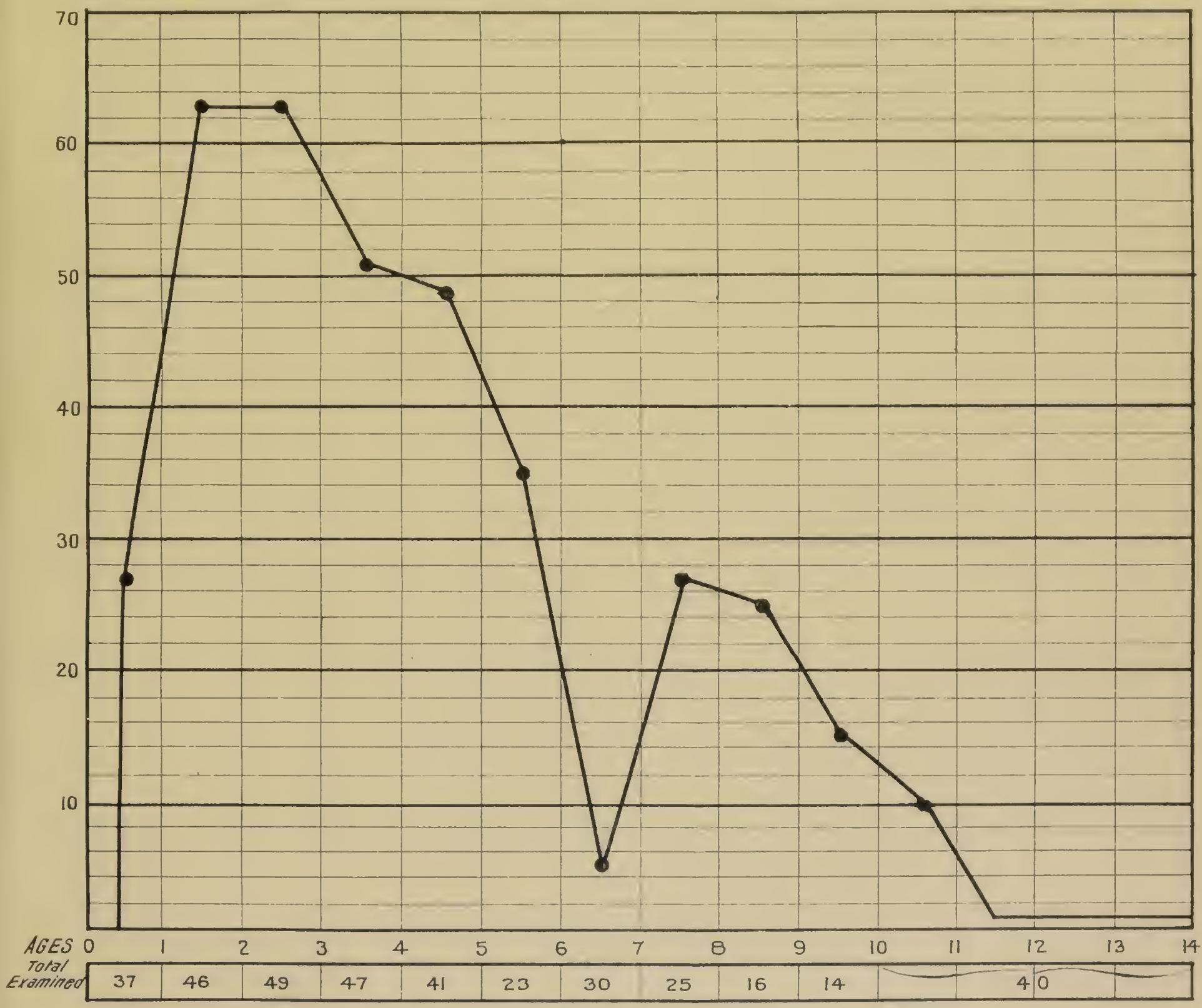


Table shewing relation of age to Percentage of infected Children.

proportional numbers of the cases varying according to the time of the year. It will be noted in the following list that crescents (gametocytes) were frequently met with in native blood, and often several were found in each specimen—they are seldom seen, and then only exceedingly few (one or two per blood smear) in the blood of Europeans in West Africa. In the report[1] of the Royal Society's Commission, it was stated, as the opinion of its members, that quartan and tertian parasites do not exist in West Africa, but our specimens, which exhibit all stages of these parasites, from the young forms to fully matured sporocytes and gametocytes, negative this opinion. It must be pointed out that no crescents were observed by them in the blood of native children.

A. Children of Bonny Town

Age	No. Examined	Result	
0-1	6	All negative	The actual ages, where accurately noted, were three, eight, six, eight and eight months respectively
1-2	6	4 positive	(1) Shewed four crescents (2) An occasional aestivo-autumnal ring form (3) Numerous aestivo-autumnal ring forms (4) One crescent ; one large and two small quartans
2-3	7	3 positive	(1) An occasional ring form ; all stages of quartan parasites (2) Numerous aestivo-autumnal ring forms—all stages (3) " " " " " "
3-4	16	9 positive	(1) Two crescents (2) An occasional aestivo-autumnal ring (3) Seven crescents (4) Several aestivo-autumnal rings (5) Few aestivo-autumnal rings (6) A single crescent (7) A few aestivo-autumnal rings (8) Several aestivo-autumnal rings (9) Numerous aestivo-autumnal rings, mostly of large size
4-5	7	2 positive	(1) An occasional aestivo-autumnal ring (2) Few aestivo-autumnal rings
5-6	3		
6-7	4		
7-8	3	2 positive	(1) Three aestivo-autumnal rings seen (2) Numerous aestivo-autumnal rings—all stages
8-9	2		
9-10	1		
10+	12	1 positive	(1) Numerous aestivo-autumnal rings : actual age twelve-thirteen years

B. Herbert Jumbo's Plantation—Bonny

Age	No. Examined	Result	
0-1	2	Negative	Ages : six months and unknown, respectively
1-2	7	2 positive	(1) Several aestivo-autumnal rings (2) Several small and one large quartan form
2-3	4	2 positive	(1) Occasional ring form (2) Numerous ring forms and all stages of quartan
3-4	6	4 positive	(1) Few aestivo-autumnal rings (2) Occasional aestivo-autumnal rings (3) " " " " (4) Few aestivo-autumnal rings
4-5	6	3 positive	(1) Numerous ring forms and all stages of quartan (2) Numerous tertian parasites (3) Several quartan parasites
5-6	2	1 positive	(1) Numerous aestivo-autumnal rings
6-7	4	1 positive	(1) All stages of quartan parasites
7-8	2	1 positive	
8-9	6	2 positive	(1) Very occasional aestivo-autumnal ring (2) Numerous tertian parasites
9-10	1		
10+	18	1 positive	(1) Several aestivo-autumnal rings : age 10-11 years

C. Juju Town

Age	No. Examined	Result	
0-1	1		
1-2	11	8 positive	(1) All stages of quartan parasites (2) Few aestivo-autumnal ring forms (3) Numerous „ „ „ (4) „ „ „ „ (5) „ „ „ „ (6) An occasional ring form (7) „ „ „ „ and a few quartan forms (8) All stages of quartan
2-3	12	8 positive	(1) Few aestivo-autumnal rings (2) An occasional ring form (3) Several young and a few mature quartan forms (4) Few aestivo-autumnal rings (5) Numerous aestivo-autumnal rings (6) Two crescents (7) Several aestivo-autumnal rings (8) Several young quartan parasites—also sporulating forms
3-4	9	5 positive	(1) A large, a medium sized, and a small tertian parasite (2) Many aestivo-autumnal rings (3) Few „ „ „ (4) „ „ „ „ (5) „ „ „ „
4-5	12	7 positive	(1) All stages of quartan (2) Very numerous aestivo-autumnal ring forms (3) Several ring forms, and a few half-matured quartans (4) Several aestivo-autumnal rings (5) All stages of quartan (6) Nine quartan parasites found—almost mature (7) Few aestivo-autumnal rings
5-6	4		
6-7	10	1 positive	(1) An occasional ring form
7-8	9	4 positive	(1) Few aestivo-autumnal rings (2) Several aestivo-autumnal rings (3) Very occasional ring form (4) „ „ „ and two crescents
8-9	2	1 positive	(1) Several ring forms and a few mature quartans
9-10	1		
10+	1		

D. Akwete Children

Age	No. Examined	Result	
0-1	10	1 positive	The ages given were three, nine, five, four, four, six, six, eight, and seven months, respectively (1) The positive case was eight months old and contained many young quartan forms, also a few mature and sporulating forms
1-2	4	2 positive	(1) Few aestivo-autumnal ring forms (2) ,, ,, ,,
2-3	8	3 positive	(1) Many aestivo-autumnal rings (2) Few ,, ,, ,, and two crescents (3) Several ,, ,, ,,
3-4	3	1 positive	(1) Few aestivo-autumnal rings
4-5	4	2 positive	(1) ,, ,, ,, ,, —all stages (2) Very occasional ring form
5-6	4	1 positive	(1) Several aestivo-autumnal rings
6-7	2		
7-8	5	1 positive	(1) Few aestivo-autumnal rings
8-9	1		
9-10	5		
10+	2		

E. Egwanga Children*

Age	No. Examined	Result	
0-1	3	1 positive	Few aestivo-autumnal rings ; age 6 months ; had a temperature of a 103° F. at time of taking blood ; negative cases, ages 2 months and 5 months
1-2	4	3 positive	(1) Numerous aestivo-autumnal rings (2) Few „ „ „ (3) Many quartan forms—all stages
2-3	8	7 positive	(1) Few aestivo-autumnal rings (2) Numerous aestivo-autumnal rings (3) Very numerous aestivo-autumnal rings (4) Several aestivo-autumnal rings—one crescent (5) Numerous aestivo-autumnal rings (6) Several aestivo-autumnal rings (7) A few crescents
3-4	3	2 positive	(1) Few aestivo-autumnal rings (2) „ „ „ several crescents
4-5	2	1 positive	(1) Few aestivo-autumnal rings
5-6	2	1 positive	(1) Few ring forms, one large quartan parasite
6-7	2		
7-8	0		
8-9	1	1 positive	(1) Very few ring forms
9+	0		

* Since going to press Dr. Hanley, of Opobo, has forwarded more blood smears of native children at Egwanga, which have also been examined.

(1) Age about 6 years—Several ring forms
(2) „ „ 8 „ Negative
(3) „ „ 5 „ Negative
(4) „ „ 5 „ Negative
(5) „ „ 4 „ Many large ring forms
(6) „ „ 4 „ Few ring forms
(7) „ „ 9 „ Two ring forms seen
(8) „ „ 8 „ Numerous quartan parasites—many sporulating
(9) „ „ 5 „ Negative
(10) „ „ 5 „ Many aestivo-autumnal rings
(11) „ „ 10 „ Negative
(12) „ „ 6 „ Numerous aestivo-autumnal rings
(13) „ „ 6 „ Occasional ring form
(14) „ „ 15 „ Negative
(15) „ „ 6 months—Few ring forms, three crescents

F. Onitsha Children

Age	No. Examined	Result	
0-1	0		
1-2	4	2 positive	(1) Several aestivo-autumnal rings (2) Numerous aestivo-autumnal rings
2-3	2	2 positive	(1) Two crescents (2) Few aestivo-autumnal rings
3-4	5	1 positive	(1) Many quartan parasites
4-5	4	1 positive	(1) Few quartan parasites
5-6	4	2 positive	(1) Occasional ring form (2) „ „ „
6-7	5		
7-8	2	1 positive	(1) A single crescent
8-9	1		
9-10	2		
10+	0		

G. Akassa

Age	No. Examined	Result	
0-1	3	1 positive	(1) Several aestivo-autumnal rings (5 months)
1-2	2		
2-3	1	1 positive	(1) Few aestivo-autumnal rings
3-4	1		
4-5	0		
5-6	2	2 positive	(1) Few aestivo-autumnal rings (2) „ „ „ „
6-7	1		
7-8	2	1 positive	(1) Numerous aestivo-autumnal rings

H. Asaba—Soldiers' Children

Age	No. Examined	Result	
0-1	5	3 positive	(1) Very occasional ring form : age 5 months (2) Numerous tertian parasites—all stages (3) Few ring forms, and a few half-matured tertian forms
1-2	1	1 positive	(1) An occasional ring form
2-3	2	2 positive	(1) Numerous aestivo-autumnal ring forms : one crescent (2) Few ,, ,, ,, ,,
3-4	3	2 positive	(1) Several aestivo-autumnal ring forms (2) Numerous ,, ,, ,, ,, two crescents
4-5	2	2 positive	(1) Few ,, ,, ,, ,, ,, (2) ,, ,, ,, ,, ,,
5-6	0		
6-7	2		
7-8	1		
8-9	2		
9-10	2	2 positive	(1) Few aestivo-autumnal rings (2) A very occasional ring form

I. Lokoja Town

Age	No. Examined	Result	
0-1	0		
1-2	1	1 positive	An occasional ring form
2-3	1		
3-4	0		
4-5	2	1 positive	Two crescents
5-6	6	1 positive	A single ring form seen
6-7	0		
7-8	1	1 positive	A single crescent
8-9	1		
9-10	2		
10+	7	2 positive	(1) Age 12-13 years ; few large quartan forms (2) Occasional ring form : age 10 11 years

J. Lokoja—Barracks

Age	No. Examined	Result	
0-1	7	4 positive	(1) Few aestivo-autumnal rings—one crescent (2) Several „ „ „ (3) Numerous aestivo-autumnal rings (4) An occasional ring form
1-2	6	6 positive	(1) Several aestivo-autumnal rings (2) Numerous „ „ „ (3) An occasional ring form (4) Numerous aestivo-autumnal rings (5) „ „ „ „ (6) „ „ „ „
2-3	4	3 positive	(1) Few „ „ „ (2) Several „ „ „ (3) An occasional ring form
3-4	1		
4-5	2	1 positive	(1) Several aestivo-autumnal rings
5-6	1		

Haemamoebidae in Europeans. The habit of taking quinine, prevalent among Europeans in West Africa, on every occasion of indisposition, makes the examination of their blood, during an attack of malarial fever, very difficult. Occasionally we met with a case which showed numerous parasites in every field of the microscope, but more generally found very few, and often no parasites at all. It is common experience that parasites often rapidly disappear from peripheral blood on the administration of quinine.

Dr. Hanley, the District Medical Officer at Opobo, was kind enough to make specimens of blood smears for us from all the Europeans available in his district, independent of the presence of an attack of 'fever' at the time. The results, with some remarks, are given in the following table :—

Name	Length of present stay on coast	Total time on the coast	Result and Remarks
F	4 months	...	Has had 7 years on the Coast, then 7 years away previous to present visit. No parasites
H	10 months	...	Negative
P	16 months	...	Negative
A	2 years and 4 months	10 years	Negative. Has had but little fever. Haemoglobin estimated at 65 per cent.
R	4 months	...	Negative. Had attack of fever 15 days after arrival on Coast
R (2nd specimen)	4 months	...	Showed a very occasional ring form. Temperature at time of taking specimen, 101° F.
P	5½ months	10 years	Negative. Haemoglobin estimated at 80 per cent.
H	18 months	...	3 ring forms found
T	...	30 years	Has an enlarged spleen reaching midway between the umbilicus and the symphysis pubis. Has had fairly good health. Examination of blood, negative. Haemoglobin estimated at 30 and 20 per cent. on the two occasions
T (2nd specimen)	...	...	
G	...	2nd voyage	Negative
McI	12 months	...	One crescent found. Has had bad health lately. One attack of fever eight months after arrival
T	...	2nd voyage	Negative
B	6 weeks	2nd voyage	Negative
M	8 months	...	Negative
T	6 months	11 years	Negative
M	2 years and 4 months	8 years	Negative
D	4 months	6 years	Negative
M	6 months	...	Negative
H	9 months	...	Negative

Other Haemamoebidae

Haemamoebidae danilewskii was found in a large number of birds, viz. :—

Columba livia	(The common pigeon)
Turtur senegalensis	(The wild dove)
Passer diffusus	
Ceryle rudis	(Black and white kingfisher)
Cypselus affinis	(Humming bird)
Alcedo guentheri	(Blue and red kingfisher)

At Old Calabar a flock of pigeons (common tame pigeon), obtained from the native town, were found infected with *Halteridium* throughout, while at a European factory among pigeons which had been in the country for nine months none were found to be infected. The factory was at some distance from native dwellings, and the pigeons had never mixed with any from the native town. Similarly some pigeons from Bugama, which had been in the country some eighteen months, were not infected—they had no opportunity of contact with pigeons from the native town, which is some two miles distant.

At Lokoja a number of tame pigeons were examined—they were obtained from different sources : some were infected, others not—they had lived in contact some weeks.

Our own collection of pigeons, some of which were infected, were together in a wooden cage for some three or four months, but infection remained limited to those originally infected.

Attempts were made to cultivate *Halteridium* in mosquitoes of both genera, but they failed completely.

Haemamoebidae relicta—Proteosoma was never found, although hundreds of birds of many different kinds were examined.

Other blood parasites—Numerous domestic fowls and a number of small bats were examined, but no blood parasites were found.

IV. SOME POINTS ON THE BIONOMICS OF *ANOPHELES*

Breeding-places.—Throughout such an extensive country as Nigeria, it was natural to expect considerable diversity in the conditions under which mosquitoes of this genus breed. The conditions varied roughly in the three different belts of country already described, and mixed conditions occurred where one belt emerged into the next.

In the region of mangrove swamps the native dug-out canoes are almost entirely the habitat of *Anopheles* larvae and pupae, for instance at Bonny, Okrika, Opobo, Bakana Town.

The canoes containing larvae are generally old and unused, and drawn up on to the foreshores of the rivers or the edges of the creeks into the neighbourhood of the native huts. There are, in places, a considerable number of these, which are now and then augmented by the addition of other canoes during a period of rough 'sass' weather. They are always more or less full of water according to the rainfall, and many have a green (protococcus) growth on their sides, or contain algae.

Only occasionally are 'puddles' containing larvae to be found in these mangrove districts, and it may be mentioned here that quite as often *Anopheles* larvae are found in water in the bottoms of broken gin bottles, in old calabashes, on the tops of barrels, in tubs, and old iron pots.

In the neighbourhood of European dwellings in this district, consisting mainly of those of Government officials and traders, and usually built on made sites, it is found that the breeding places of *Anopheles* have been ignorantly made by the 'white man' himself. They consisted of 'duck ponds,' cemented or tubbed in (larvae are, however, never found when ducks frequent these ponds), shallow wells, with their sides protected by a palm oil puncheon or other barrel, and occasionally uncovered rain barrels. In some places, *e.g.*, round the Consulate at Opobo, the nature of the surface is such as to favour the formation of a small fresh water marsh, in the puddles of which larvae exist.

On the small areas of fertile land, which are here and there interspersed on the river banks in the midst of the mangrove swamps, and on which the 'factories' of the various trading companies are usually built, the breeding places of *Anopheles* consist of shallow puddles, scattered here and there, permitted by the unevenness of the surface and lack of any systematic attempt at surface drainage. These 'puddles' are kept full of water during the wet season, and are frequent along the footpaths crossing the areas, and along the sides of warehouses. In fact, the presence of the enormous number of mosquitoes at the factories at Slave Trees, Bakana, and at

Portion of the Foreshore at Old Calabar

THE UNUSED DUG-OUT CANOES ARE MORE OR LESS FULL OF WATER CONTAINING *Anopheles* LARVAE
ON THE RIGHT IS THE FACTORY OF A EUROPEAN TRADING FIRM ; THE NATIVE HUTS
ARE BUILT CLOSE UP TO ITS WALLS

Bugama, which are completely surrounded by miles of mangrove swamp, can be traced to no other source. At the African Association's factory at Slave Trees, no other breeding places can exist. The small area on which the factory stands is cleared, and surrounded also by a mud swamp covered by tidal water twice a day. Here myriads of *Anopheles* were encountered.

In the region above the mangrove swamp — the forested belt — the natives are more of an agricultural than a fishing race, and consequently the 'dug-out' canoe is considerably less in evidence as a breeding place, except in towns on the river banks. This district is flat, and its surface clayey. The natives build their huts of clay, dug out of pits in the immediate neighbourhood of their huts. These often contain water in which *Anopheles* larvae are easily found. In addition, 'puddles' are also present in hollows either weathered or worn out in the clayey surface. In the large ponds and in the pools in the neighbourhood of springs from which the native obtains drinking water, and which generally contained fish, we were never able to find larvae, except in the small pieces of water locked off at the edges as the level of the water fell. These conditions obtain at Onitsha, Abutshi, Asaba, Abonnema, Degema, and Egwanga.

In the immediate neighbourhood of European dwellings in this district, bad surface drainage, or the proximity of clay pits from which the 'boys' obtain mud for huts, or of wells from which they obtain their drinking water, supply sites for *Anopheles* larvae.

In the region above the forested belt, the country merges into a tract of deforested, more or less open, country, undulating and hilly, sparsely wooded, and covered with a short scrub. Here the breeding places of *Anopheles* consist of the pools, and back eddies, and sluggish corners in the course of the small streams running between the hills, of the badly-made ditches along the sides of roughly constructed roads and footpaths ; and occasionally, in swampy districts, of the furrows between the butts and drills of cultivated fields. Such conditions obtain at Lokoja, in Northern Nigeria.

During the period of the expedition's visit to the river Niger, the rainy season prevailed. This river, which, in the height of the dry season (December to March), is reduced to the condition of a small sinuous canal, only admitting of the passage of launches drawing less than three feet of water, rises during the wet season a height of forty feet, and expands into a great river, reaching in parts a breadth of one to one-and-a-half miles. During the fall of the stream in the dry season it is said that numerous pools are left on the sloping banks, which afford breeding places for innumerable *Anopheles*. In some places, such as Asaba, a most rigorous search, both along the river banks and inland during the wet season, failed to reveal any breeding places for *Anopheles*. Pits from which mud is obtained for hut-building purposes are common ; almost each compound has its clay pit, partially filled with clayey

water, often quickly drying up in the hot sun, occasionally so replenished by rain showers as to be for a period more or less full of water ; some, however, deep, and always containing water. They also serve in many places as duck ponds. They were examined time after time but no larvae found, although a few *Anopheles* adults could always be procured in the houses in the neighbourhood. It has been surmised that the chief breeding-places of *Anopheles* in these parts are the pools on the river banks above mentioned, and that during the greater part of the wet season *Anopheles* do not breed copiously. Whether this is so, only careful observation during the dry season can determine.

It is to be remarked that *Anopheles* larvae were never found in the bush or at any great distance from human habitation. The greatest distance observed was under half a mile. Near Old Calabar, at a point some two or three miles in the bush, is a spring, which is intended to be utilised for the water supply of Old Calabar. Engineering operations have already been commenced, and a well bricked in to the depth of some eight feet. The immediate neighbourhood of the well is flooded. Innumerable *Anopheles* larvae were found here. The spring occurs at the bottom of a natural depression in the surface, some eighty or a hundred feet deep, which is surrounded with thick forest growth, and approached only by narrow foot-paths. The only habitations in the neighbourhood are a small hut on the edge of the depression, and another one about half a mile along one of the paths. Two native villages occur at a distance of about a mile. The spring is visited daily by scores of natives for drinking water, and a number of labourers are at present carrying out engineering operations. The occurrence of such an extensive breeding-place away from any large collection of natives is extremely remarkable.

The fact that *Anopheles* larvae are occasionally found in those sites which are generally occupied by *Culex*, namely, broken bottles, calabashes, iron pots, barrels, etc., tends to suggest that in places where the natural breeding-places of *Anopheles* become, either from scarcity of rain or in consequence of artificial destructive means, very scarce, *Anopheles* will make use of any available water which will last sufficiently long for the purpose of laying their eggs. The conditions above mentioned were met with principally in the middle of Bonny native town, where the usual breeding-places, the dug-out canoes, were at some distance, and any puddle which might form on the narrow footpaths and streets was continually disturbed by the trampling of passers-by.

Breeding-places of Culex.—These consisted of sites similar to those already described by many authors as occurring in the immediate proximity of dwelling-houses in the tropics—pots, bottles, tins, cans, calabashes, tubs, barrels, iron vessels, rain tubs, water tanks, pools, puddles, canoes, cocoanut husks, the hollows at the junction of the leaves and stems of the banana tree—and any place where water lodges for a few days. Larvae were found in fire-buckets and other vessels inside houses of Europeans.

THE OLD TOWN SPRING NEAR OLD CALABAR

Anopheles LARVAE IN GREAT NUMBERS WERE FOUND IN THE WATER OF THE BRICKED-OUT WELL, AND OF THE FLOODED AREA IN ITS IMMEDIATE NEIGHBOURHOOD

Ova.—Besides the characteristic manner in which *Anopheles* ova are deposited on the surface of water, they can also be distinguished from *Culex* ova in other ways. The ovum of *A. costalis* is roughly ovoid in shape ; its length is about 0·48 millimetre, its total breadth 0·16 millimetre. The anterior end is the broader ; the superior surface is slightly concave antero-posteriorly ; this surface is broad anteriorly, narrower posteriorly, and constricted in the centre, presenting a shape somewhat resembling the sole of a boot ; it is limited on all sides by a striated border. The inferior surface, that in contact with the water, is convex.

The chitin of the lower surface is beautifully marked with hexagonal figures, which are well seen in an empty egg case. The upper surface has no such markings, but at each end has five very small rounded bosses of transparent chitin. The distinguishing feature of the *Anopheles* ovum, pointed out by Ross,[2] is the presence of two lateral wings of transparent cuticle. These have a width of about 0·02 millimetre, and are about 0·3 millimetre long. They are attached one on either side of the ovum throughout the greater part of its length. This cuticular structure has a wide, oval area of attachment, extending below in a semi-circular manner on to the inferior surface, but limited above by the serrated edge of the upper surface. It is hollowed out on its upper surface. The free outer edge is serrated, the whole surface presenting a milled appearance. Slight maceration of the ovum separates this structure from the egg case.

The larva lies with its head situated at the broader end of the egg case. The top of the anterior end of the egg case is broken off in a spiral manner to allow of the escape of the larva.

It was noted that when mosquitoes of the genus *Culex* are forced to lay their eggs on a small surface, *e.g.*, on water in a narrow test tube, the eggs are arranged in a pattern very similar to that of *Anopheles* ova.

When freshly laid, the eggs are whitish in colour, becoming black in the course of an hour.

Actual countings of the number of ova deposited at one laying gave the following numbers : 138, 145, 233, and 179.

Larvae.—*Anopheles* larvae were occasionally found infected with a parasite (*Brachionus*) which caused them to present a fluffy appearance and hindered their growth, so that they continued in the larval stage for an abnormally long period, and at length died.

The numbers of males and females which hatched out from a number of larvae were counted on several occasions—396 larvae produced 185 males and 211 females.

Habits of Adult Anopheles.—In the preceding paragraph it is seen that the numbers of male and female *Anopheles* which hatch out from a batch of larvae are

approximately equal. Nevertheless, out of a large number of *Anopheles* collected inside European and native quarters but very few males were present ; from notes made at the time we counted only 22 males to 293 females, but the proportion is probably only about half that, since many females were taken without note being made of their number.

As to what becomes of *Anopheles* during the day, no exact facts have been observed, and whether the majority remain hidden in the darker parts of habitations, or hide among vegetation, is not absolutely certain. But after sunset, clouds of mosquitoes were often observed flying and hovering in characteristic flocks in the neighbourhood of native huts, about eight feet above the ground. On capturing and examining many of these, all were found to be *Anopheles* males.

In native huts it is never difficult to obtain *Anopheles* females ; a large number are always found, for example, in the Kroo boys' huts, while perhaps in the European dwelling-house only an occasional one can be caught. In fact, we found it a good practice in many parts where *Anopheles* were apparently scarce in European quarters, to provide the native boys who acted as our servants with mosquito curtains (they often craved for these) ; a number could be obtained in this way every morning inside the curtains, which had been badly applied by the 'boys.' Many of the Kroo boy servants make themselves rough curtains of any 'cloth' they can obtain ; these invariably provide a supply of *Anopheles*.

It is popularly believed that mosquitoes, and more especially those of the genus *Anopheles*, bite only during the evening and night. It is common experience that many of the genus *Culex* bite during the day time ; and, as to *Anopheles*, we have often observed these insects alight on different parts of us, and feed voraciously, in broad daylight. It probably depends very considerably on circumstances. If a feed of blood cannot be obtained at evening or night time when the great majority of these insects feed, then they will bite in the day time. For instance, in offices occupied only during the day time, we were able to find *Anopheles* with distended abdomens. In fact, in the darker parts of the rooms, under tables and desks, behind chairs, etc., *Anopheles* were always to be found ; and here they rest until an opportunity of feeding is presented to them, be it day or night ; or maybe they are disturbed, fly about, and often attack the intruder.

Considerable evidence has now been accumulated to prove that the distance which is traversed by a mosquito is never very great, and extremely rarely reaches so much as half a mile. The fact that their breeding places are always within a short distance of some dwelling, and have only very rarely been found at a distance even of half a mile, negatives the probability of a long flight. The outbreaks of malarial fever on board ships whose crews had never left the ship, were explained when mosquitoes of the genus *Anopheles* were collected on board ships in malarious districts; and cases occurred which, from their long period of incubation, required as an

explanation that these insects should be carried on board for a considerable time after leaving the malarious district. The experience of the expedition afforded proof of the truth of this surmise. In making the tour of the 'creeks' behind Bonny, on board the s.s. 'Sobo,' the first stopping place was Slave Trees, Bakana. This place is renowned in those parts for the number of its mosquitoes, which, as has been previously mentioned, are almost all of the genus *Anopheles*. The ship anchored about a quarter of a mile from the shore; at night mosquitoes came on board in large numbers. In the cabins and saloons were great numbers of them. One night only was spent here. But for a week afterwards *Anopheles* could be observed in the darker corners of the saloons, and even ten days afterwards an occasional one could be caught, although the ship has been out to sea again in the meantime, in fact, had reached Opobo River. Probably in the smaller and closer quarters of the sailors they would have been found still later.

In the report of the expedition to Sierra Leone, the following observations of the propagation of *Anopheles* occur :—

'We also observed that while naturally-fed gnats invariably laid eggs after two or three days, those which had been bred from the larvae in captivity, and had then been isolated and fed in test tubes, *never* did so, although before being isolated they had long been in company with males. The inference is that fertilisation takes place only after the female has been fed. We noted also that, in a cage where many male and female gnats, both *Culex* and *Anopheles*, were kept together for weeks, eggs were never laid—although the insects were fed, as described, on bananas, and the cage contained water for them to lay their eggs in. It seems, then, that a meal of blood is necessary before fertilisation. Lastly, we observed that previously fed and fertilised insects would lay a second batch of eggs after a second meal of blood, without a second fertilisation; but never laid a second batch of eggs without a second meal of blood. That is, one fertilisation suffices for several batches of eggs, but one meal of blood for only one batch of eggs.'

This is summed up in the following sentence—'Although these gnats (*Culicidae* which feed on men) can live indefinitely on fruit, and perhaps juices of plants, the female requires a meal of blood, both for fertilisation and for the development of her ova. In other words, *the insects need blood for the propagation of their species*.'

Proof of the truth of these inferences is afforded by a series of experiments which we carried out, chiefly at Bonny.

Experiment I—Four male *Anopheles* and five females hatched from pupae were placed together in a cage with a small pool of water and fresh banana: all died in four or five days, having laid no eggs; on dissection, the ovaries were found undeveloped.

Experiment II—Repeated the experiment with thirty to forty mosquitoes of each sex. It was noted that many, both males and females, fed on the banana immediately on introduction. All died in nine or ten days; no ova laid.

Experiment III—A number of male and female *Anopheles* were introduced into a cage with water and banana. The females were all fed on blood *once* only, before introduction ; all died within four days—no ova in water or in insect.

Experiment IV—Repeated this experiment with a large number of males and females. The females fed once on blood, afterwards on banana and water. Some few lived twelve days, all were dead on fourteenth ; no ova found. Ovaries undeveloped ; spermathecae empty.

Experiment V—Introduced into a cage a number of females and males, the females had not been in contact with males before feeding : they were fed only once on blood. Five days afterwards, no eggs having been laid, a further number of males and females were introduced, the females having been in contact with males since birth—and having had one feed of blood. Banana and water were kept freshly supplied daily in the cage. All died within eighteen days from the first, thirteen days from the second introduction ; no eggs having been laid.

Experiment VI—A number of *Culex* males and females were placed in a cage with banana and water ; they had no blood ; but lived for sixteen days—laying no eggs.

Experiment VII—A number of *Culex* males and females introduced with banana and water. The females were fed on blood on introduction and again seven days afterwards. Eggs were laid on the ninth day of the experiment, two days after the last feed of blood.

These experiments were performed in small cages, made of mosquito netting, of size about twelve inches long, twelve inches deep, and six inches wide.

Among mosquitoes of the genus *Culex*, copulation was often observed in the small cages of our experiments, but with *Anopheles* never. It was thought possible that these latter required a longer flight than could be obtained in cages of the dimensions given, so that our next experiments were made with a large cage eight feet long by six deep by four wide, into which were introduced a small iron tank and a soil puddle in an earthenware vessel containing water and a number of peeled bananas which were daily replenished.

Experiment VIII

June 8 Thirteen newly-hatched males and twelve newly-hatched females (*Anopheles*) were introduced into the large cage, the females have been fed on the blood of one of us.

„ 9 Introduced some males caught in native quarters and four newly-hatched, blood-fed females.

„ 10 Introduced eight blood-fed females and a number of males, all newly-hatched out.

„ 13 Re-fed thirteen of the above females, some would not feed, others had died.

June 15 Re-fed nine of the above females; introduced ten more freshly-hatched, blood-fed females and ten males, three of which were caught in the native town; three females were found dead on the water.

„ 17 Re-fed thirteen females; one found dead on the water; showed undeveloped ovaries and empty spermatheca.

„ 19 Re-fed eleven females; introduced three caught males from the native town.

„ 21 Re-fed ten females; only one living male can be seen. First noticed the ovaries beginning to swell as a greyish patch on upper surface of abdomen.

„ 23 Re-fed eight females.

„ 24 Re-fed six females; no males can be seen.

„ 26 Re-fed eight females; one female was accidentally killed while feeding. Ova were found fully developed enclosed in their usual chitinous ridged capsule. No spermatozoa in the spermatheca.

„ 28 Re-fed nine females—all except one shewed distended abdomens

„ 30 Introduced three females caught in native town. Re-fed nine females.

July 2 Re-fed eight females.

„ 5 Re-fed six females; eggs were found on the surface of the water in the small iron tank. All the females were apparently full of eggs except one, presumably the one which had laid the eggs. This mosquito was caught and kept by herself in a small cage.

July 7	Only four females remain in the large cage, two of which would not feed—also two males present.	The isolated female was re-fed on blood.
„ 9	Re-fed four females in large cage.	This female laid more eggs; she was again re-fed. The ova of the 5th had not hatched out.
„ 11	Re-fed four females.	More eggs laid; re-fed with blood; eggs of 5th and 7th had not hatched out.
„ 12	The four females and two males remaining in the large cage were removed and placed in a small cage.	Few more eggs laid. None of the previous eggs hatched.

July 13	One female found dead on the surface of the water with developed ova and empty spermatheca. Others re-fed on blood.	Re-fed on blood ; abdomen swelling.
,, 16	One female dead on water ; contained developed ova. Other two females re-fed.	Laid more eggs. Was re-fed on blood.
,, 18	Re-fed ; no ova laid.	Re-fed.
,, 20	Re-fed ; no ova laid.	Re-fed ; more eggs had been laid. None of the previous eggs had hatched.
,, 21	Added eight males to this cage.	Added four males to this cage.
,, 23	One of the two females had died ; contained ova with transparent cuticle ; empty spermatheca.	Six eggs laid. Re-fed on blood.
,, 25	The remaining female died.	Re-fed. Abdomen again swelling.
,, 27		Few eggs laid. Re-fed on blood.
,, 29		Found struggling on the surface of the water ; had lost one leg ; was killed. Ovaries contained thirty-three developed ova with chitinous covering ; empty spermatheca. None of the eggs laid hatched out.

This experiment was repeated in a small cage entirely.

Experiment IX

June 26	Ten females (*Anopheles*) hatched out from pupae, were fed on blood and introduced with a number of hatched-out males, into a small cage with banana and water.
,, 28	Eight of the females were re-fed on blood ; four males caught in the native town were added.
,, 30	Eight again re-fed ; three more town males introduced ; abdomen beginning to swell.
July 2	Re-fed eight females.
,, 5	Re-fed seven females ; two males found dead on water ; eggs laid.
,, 6	Eggs of yesterday hatched out.

July 7 More eggs laid ; re-fed four of the five remaining females, the other would not feed.

„ 9 Eggs of seventh hatched out. Re-fed four females ; one would not feed.

„ 11 Few more eggs laid. Re-fed two females ; three would not feed.

„ 12 Eggs of yesterday hatched out.

„ 13 Re-fed five females ; no more eggs laid.

„ 16 Re-fed three females ; numerous eggs laid ; one female dead on the water ; two appeared thin.

„ 17 Eggs of 16th hatched out.

„ 18 Re-fed four females ; one would not feed ; no ova.

„ 20 Re-fed three females ; eggs laid.

„ 21 Placed more males in cage. Eggs of yesterday hatched.

„ 23 Re-fed one female ; others escaped.

„ 25 The remaining female would not feed ; more eggs laid.

„ 26 Eggs of yesterday hatched out.

„ 27 Remaining female dead on water.

Thus our surmise that a long flight was required for copulation proved false, since the ova in the second of the two experiments just detailed had been fertilised and hatched out. Why fertilisation did not take place in the larger cage is difficult to explain, unless owing to the comparative small number of mosquitoes, both males and females, in so large a space, the opposite sexes seldom met. It is to be noted that in this experiment eggs were laid in water in an iron tank preferably to that in an artificial soil puddle, and further, that although fertilisation did not take place still the ovaries developed apparently normal ova, which, however, did not produce larvae.

It is further to be remarked that, with a regular supply of blood (every other day), eggs are laid within eight days of the birth of the adult female from the pupae; and that they continue to be deposited every second or third day afterwards, if water is available, until the death of the insect.

In these experiments it is seen that females in confinement in cages may live and be fertile for a period of at least seven weeks ; from which it may be surmised that under natural conditions they might live much longer.

The following experiment shows that even in the absence of males, the ovaries develop ova.

Experiment X

July 17 Introduced five females hatched from pupae ; no males added. The females were fed on blood.

July 19 Re-fed the females.
„ 22 Re-fed the females.
„ 25 Five females re-fed.
„ 27 Re-fed two females.
„ 29 Re-fed two females ; ovaries beginning to swell.
„ 31 Re-fed the two females.
Aug. 2 Re-fed the two females ; swelling of abdomen more pronounced
„ 4 Again re-fed.
„ 7 Re-fed.
„ 9 Re-fed.
„ 11 Would not feed.
„ 13 One had disappeared ; the other would not feed.
„ 15 Re-fed both females ; abdomen very swollen ; no eggs laid.
„ 19 Both had disappeared. (Probably eaten by ants).

In order to show that blood is necessary for the development of the ovaries and the formation of developed ova, the following experiment was performed. The females were not fed on blood.

Experiment XI

July 8 Ten females introduced into a small cage with a number of males caught in the native town ; no blood was given ; banana and water also placed in cage.
„ 16 Ten females still alive ; the banana was replenished every day.
„ 18 Eight females alive ; no eggs ; one dead female examined showed undeveloped ovaries.
„ 21 More males caught in native town introduced.
„ 25 One female dead on the water ; showed undeveloped ovaries.
„ 27 Only one female left ; no eggs laid.
„ 29 All dead ; no eggs laid.

Thus, without feeding on blood, female *Anopheles* may live at least twenty-two days on vegetable juices alone, but the ovaries remain undeveloped, although many males may be present.

The next experiment indicates that a regular and frequent blood feed is necessary—as often as every other day, every fourth day being insufficient—for the development of ova.

Experiment XII

July 18 Ten female *Anopheles*, bred from pupae, introduced into a small cage with six males caught in native town.
„ 20 Two females had died.

July 21 More caught males were added.
„ 23 Re-fed five females ; one would not feed ; others had died.
„ 27 Re-fed three females ; two dead on the water showed undeveloped ovaries, and empty spermathicae. Added five more males from native town.
„ 29 All had died.

The following three experiments were undertaken to ascertain whether males from a certain batch of eggs from one adult female could fertilise the females of the same batch ; Experiments XIII and XIV seem to contradict one another in their results. They also serve to show that the males directly after hatching reach sexual maturity very quickly, and are able to fertilise.

Experiment XIII

July 1 Nine females developed from pupae were fed on blood of one of us and introduced into a small cage together with banana and water.
„ 3 Nine females re-fed.
„ 5 Re-fed eight females.
„ 7 Re-fed six females ; one dead on water ; abdomens swelling.
„ 9 Re-fed five females ; one would not feed ; no eggs laid.
„ 11 Re-fed six females ; one egg found on water.
„ 13 Re-fed five. One would not feed.
„ 15 Re-fed five. Few eggs laid irregularly on water ; one female dead on water shewed fully developed ova with chitinous covering.
„ 18 Re-fed two females ; three would not feed ; single egg of 11th had disappeared ; those of 15th had not hatched out.
„ 20 Re-fed four females ; one would not feed ; more eggs laid ; those of 15th had not hatched.
„ 23 Re-fed three females ; one dead ; more eggs laid.
„ 25 Females would not feed.
„ 27 Re-fed three females ; no males present ; more eggs laid.
„ 29 Females would not feed.
„ 31 Two females dead ; one only fed ; no more eggs. Introduced six freshly-hatched males into cage.
Aug. 2 Some eggs on water ; pregnant female dead—ovaries contained eggs with chitinous covering. Eggs of 27th not hatched.
„ 4 Eggs of 2nd not hatched.

Experiment XIV

Aug. 7 Placed in small cage twelve females fed on blood, with a number of males hatched from the same batch of eggs of an adult female *Anopheles*.
„ 9 Re-fed.
„ 11 Re-fed.
„ 13 Re-fed.
„ 15 Re-fed.
„ 17 Re-fed.
„ 19 Re-fed ; eggs laid, but accidentally lost.
„ 21 Re-fed ; more eggs laid.
„ 23 Re-fed two of the remaining three females ; the other would not feed. The eggs of 21st hatched out.
„ 25 Re-fed two females.
„ 27 Re-fed two females.
„ 29 Re-fed two females.
Sept. 1 One dead ; the other would not feed—very pregnant.
„ 3 Re-fed the remaining females.
„ 5 Dead ; no eggs laid.

Experiment XV

Aug. 7 Thirteen females fed on blood of one of us, and introduced into cage with a number of males, hatched from a different batch of eggs.
„ 9 Re-fed.
„ 11 Re-fed.
„ 13 Re-fed.
„ 15 Re-fed.
„ 17 Re-fed.
„ 19 One only remaining ; re-fed.
„ 21 Re-fed the single female.
„ 23 Eggs laid ; the mosquito dead.
„ 24 Eggs of 23rd hatched out.

Thus it does not matter whether the males and females are developed from the eggs of a single female or from different females, fertilisation occurs in both cases.

It was intended to continue these experiments after leaving Bonny, but this proved impossible under the circumstances already referred to.

They prove, however, the following points :—

(1) That a purely vegetative existence is insufficient for the propagation of mosquitoes of the genus *Anopheles*.

(2) That blood is necessary for the development of ova.

(3) That the blood must be available regularly—at least every two days—for the development of ova.

(4) That the power of propagation of the species is acquired in a very short time after the production of the *imago*, and is extremely vigorous during the whole life of the insect if feeds of blood are available.

(5) That one act of fertilisation by the male suffices for a considerable period of ova production.

(6) That even in spite of fertilisation not having occurred, ova develop if regular feeds of blood are procurable, and may be deposited on water.

(7) That unfertilised, fully-developed ova may be carried by the female for a considerable period (four weeks in our experiments).

V. THE PREVENTION OF MALARIAL FEVER

At the commencement of this chapter, which will treat of the methods to be adopted for the prevention of malarial fever, the members of the expedition wish very strongly to indicate that the suggestions given are based on their own experiences and observations, and, as other scientific workers have as a result of their researches in other parts of the world suggested somewhat different lines of procedure with the same object in view, we consider the recommendations hereafter suggested as the most suitable, in fact the only possible, if malarial fever in the country of Nigeria is to be successfully combated. Whether they can be satisfactorily adopted in other parts of West Africa we are not, from personal observation, able to say, but it is noteworthy that the members of the only other malaria expedition which has made a long stay on the Coast—namely, the Royal Society's Commission in the districts of Sierra Leone, Accra, and Lagos, have recommended absolutely the same methods.

With a view as to the possibility of preventing malarial fever, it is to be noted that during the life history of the malarial parasite in the bodies of its two hosts—man and the mosquito (*Anopheles*)—the parasite may be attacked or avoided,

A in its intermediary host—man,

(i) during the incubation period of the disease; and

(ii) during the course of the disease.

B in its definitive host—the mosquito of the genus *Anopheles* by

(i) preventing inoculation, that is, their bites;

(ii) the destruction of the insect in any of its stages of development—as ovum, larva, or adult.

A. The only means of attacking the parasite during its life history in the intermediary host—man—at present known is by the action of quinine, either as a prophylactic during the incubation period of the disease, or as a curative measure during the course of the disease.

Professor Koch, as a result of his researches in the East Indies, has recommended the wholesale administration of quinine to Europeans and natives as the most practical method for the prevention of malarial fever in those parts. However practicable it may appear as a preventive measure in the parts visited by him, it is absolutely impracticable in West Africa. Manson[1] also suggested this as one of a number of methods for adoption throughout West Africa. There are a number of conditions which strongly militate against such a course of procedure. It has been shewn in a previous chapter that a large percentage of native children under ten

years of age, and almost all children under five years, are infected with malarial parasites, often in large numbers, and that their blood frequently contains the parasites in that stage—'gametes'—in which they are naturally fitted for the further development of their life history in the mosquito. It is evident that the mosquito, while serving as the definitive host for the malarial parasite, carries the infecting agent from the native children to other natives and to Europeans. As it is the custom throughout the whole of Nigeria and, indeed, throughout the whole of West Africa, almost universally, for the European to dwell in close proximity to the native, the children constitute continually an eminently dangerous source of malarial fever for the European. It is, therefore, evident that if the method suggested—the universal administration of quinine—be adopted, the native must be also treated—as Professor Koch suggested, and apparently carried out successfully in parts of the German East Indies. It is not sufficient that the European alone should use quinine—and, moreover, it is with difficulty that the majority of Europeans on the Coast can be prevailed upon to use quinine regularly and intelligently.

Professor Koch qualifies the possibility of the adoption of this method by the supposition that the people to be treated are an 'intelligent and obedient community.' Exceedingly few of the natives of West Africa, and especially of Nigeria, can be brought under this description—in fact it can be safely stated that throughout the whole of Nigeria, we never met with a community which could be in anyway classed as 'obedient and intelligent.' The native of Old Calabar—the seat of government in Southern Nigeria—is stupid, unintelligent, and indifferent; those of the Bonny and Opobo districts, who have been longer in contact with Europeans, are just feeling the effects of civilisation, but they still look upon any new procedure on the part of the 'white man' with superstitious distrust and perplexity. The natives of other parts of the delta and of the Niger banks are mostly uncivilised, and often run away at the sight of a European: while there are towns in the interior only occasionally visited by 'white men,' or which are absolutely unopened. It is true that the native chiefs are often intelligent and educated men, but these are exceedingly few. It is extremely doubtful whether in such towns as Sierra Leone, Accra, Cape Coast Castle, and Lagos, where civilisation is fairly advanced, the introduction of any such practice as Professor Koch suggests, is at all possible. It is evidently absolutely impossible for Nigeria, even if the cost and freightage of the immense quantities which would be necessary for the purpose, did not put it completely out of question—for there are numbers of towns of population exceeding 5,000, some even reaching 30,000 and 50,000, and even more.

Among Europeans in West Africa, the usual practice as to the taking of quinine as a prophylactic, is to take five grains every day, or five to ten grains when they feel a little indisposed, 'out of sorts,' or when they think of it. Of the inefficiency of the latter as a preventative measure there can be no doubt, and it is

very doubtful whether, by the cultivation of a habit, the former is of any value. Furthermore, it is even questionable whether, in many cases, a larger dose (fifteen grains) at intervals as suggested, has not deleterious effects when taken when in apparent health. We have observed startling effects in some cases after a single administration to healthy persons of even ten grains.

B. It is by attacking the definitive host that the best results in the prevention of malaria fever have been, up to the present, anticipated.

I. Prevention of Biting by Anopheles

(*a*) *Culicifuges and Fumigation.*—The many substances which have been put forward as culicifuges to be smeared on the exposed parts of the body, or to be used as perfumes for the purpose of preventing the bites of mosquitoes, are not only obnoxious in their use but absolutely useless. Moreover, fumigation of premises can be of no practical value. The 'wily' *Anopheles* deserves its appellation to an extent little expected, and such subterfuges as smearing with kerosene, or the use of lavender and other substances can have but little effect, while fumigation is more likely to expel the European rather than the mosquitoes.

(*b*) *The use of mosquito-proof houses and of mosquito curtains.* Manson[2] advises the extensive use of these conveniences, together with a universal dosing with quinine for a period for prevention of malarial fever in West Africa. It is not evident, from the report of his suggestions available, whether the use is to be limited to Europeans only, or is to be extended to the natives; if the latter case, then the scheme is evidently impracticable, and if the former it is inefficient.

The mosquito curtain is astonishingly misused by Europeans on the West Coast of Africa. We very rarely met with one who used the curtains in a careful and proper manner. Almost all are so placed as to hang outside the bedposts and reach on to the ground, being either free or weighted. This is an improper way of hanging the curtains, which thus act as a trap for those mosquitoes which have taken shelter during the day-time under the bed—as very commonly happens. The majority of the nets were sometimes so torn as to be of no protective use whatever, others had a few holes. All these were practically useless—the persistent *Anopheles* will discover the smallest hole capable of affording its body admission in the search for blood. It was common to hear considerable surprise expressed at the presence of gorged mosquitoes inside these nets regularly every morning.

Further, it is hardly to be expected that persons who neglect the proper use of the simple mosquito curtain, will attend to the nets at the doors and windows of a mosquito-proof house. In fact, we met with such a house in a district where mosquitoes were very numerous, and found the nets in a condition very similar to that of the mosquito curtains. Apart from the impediment to ventilation which would be produced by the use of nets at the doors and windows of a mosquito-proof

house—and this is a serious consideration in climates such as that of West Africa—the habits of the European in that country expose him repeatedly to the bites of *Anopheles* at times of the day when it would be impossible for him to be inside a mosquito-proof house. The offices of the government and the warehouses and shops of the traders it would be impossible to protect in this way, while innumerable people continually enter and leave—and here many *Anopheles* are often very troublesome. Similarly, work being done for the day, it is a common practice with all the Europeans to sit out after sunset in their verandahs, or in the open, enjoying the cool of the evening—exposed to the attack of mosquitoes, which become active at this time of day.

Destruction of the Insect

(*a*) *Of adults.* This evidently can be executed to a very small extent only, and is not to be considered as of any material help to prevention. The ease with which they can be caught is, however, noteworthy—native boys soon recognised the difference between *Anopheles* and *Culex*, and brought us often as many as fifty or more of the former every day, either in test tubes or even in bottles—large numbers in each.

(*b*) *Of larvae—and the extirpation of breeding places of Anopheles.* This presents a very large field of operations against the mosquito. The extermination of the definitive host will naturally occasion the destruction of the malarial parasite.

The chief result of the previous expedition to West Africa (Sierra Leone) was to establish the fact that breeding-places of *Anopheles* are often easy of destruction or of prevention, and that this procedure would, to a large extent, prevent malarial fever in districts where it was thoroughly carried out. Two courses were suggested.

1 Efficient drainage—and the construction of proper roads—and the filling up of pools and puddles of water to prevent the formation of breeding-places.

2 The use of 'culicicides,' to be added to existing breeding-places regularly and intelligently, to kill larvae present, and to prevent future use of the water for the purpose of breeding.

Although the first method was suggested as the only really efficient measure, the second was offered as a temporary measure until the financial condition of the colony would permit of the expenditure necessary for the carrying out of the first, and also for adoption in those rarer circumstances where the more efficient method could not be applied.

The material changes which have been brought about in the prevalence of malarial fever in some towns in tropical and sub-tropical countries, especially in India and Southern Africa, by the introduction of a good drainage scheme, were previously described as the results of general sanitary improvement, and it was decidedly established, before the part played by mosquitoes in malarial infection was even hinted at, that the adoption of good drainage methods was often immediately followed by a more or less

complete disappearance of malarial fever in the district. Now, of course, such improvement must be ascribed to the destruction of the breeding-places of *Anopheles*.

As has already been shewn in previous chapters of this report, the conditions met with in Nigeria are extremely varied. Districts may be very roughly classified, according to the nature of their more common breeding-places for *Anopheles*, as follows :—

(*a*) Those in which native dug-out canoes, and occasionally shallow surface puddles are usual—for example, at Old Calabar, Bonny, Opobo, Okrika, etc. etc.

(*b*) Those with shallow surface puddles only—the areas of many of the factories of the various trading companies.

(*c*) Those having mud and clay pits, wells and pools, and few surface puddles.—Abonnema, Egwanga, Okoyong, etc.

(*d*) Those with 'made' roads, having ditches at the side and small hill streams—Lokoja.

(*e*) The neighbourhood of fresh-water marsh districts in cultivated and occasionally uncultivated areas.—Lokoja, vice-consulate at Opobo.

(*f*) Towns on the banks of rivers which fall considerably during the dry season.—Agberi, Asaba, and many others.

It must be distinctly understood that these do not include all the breeding-places of *Anopheles*, and we are of opinion that it would be extremely difficult, even in a small district, to indicate all the collections of water which might from time to time serve as breeding-places. For we urge that the destruction of the usual breeding-places of *Anopheles* would be followed by the adoption of any piece of water that might be presented if of sufficient duration, and that at length the various unlimited breeding-places usually frequented by *Culex* would be resorted to. Such a condition, however, would be rendered difficult under the circumstances of modern European domestic life.

In almost all of the classes into which districts have been placed according to the conditions under which *Anopheles* breed, an efficient surface drainage is more or less applicable. Many of the compounds of the trading companies' factories (*b*) are roughly kept, and present irregular unlevelled surfaces permitting the formation of numerous shallow puddles in the rainy season. The careful construction of a few gutters and ditches would obviate the evil, and thus destroy almost the whole of *Anopheles* breeding-places in the immediate vicinity of the factories—which often are the only source of *Anopheles*.

The numerous clay and mud pits of districts (*c*) which occur in almost every native town outside the mangrove swamp region, would be difficult to treat by drainage. From them the natives obtain mud or clay wherewith to build their huts and

new ones are continually being made—the old ones remaining unfilled. Those in the neighbourhood of European quarters could, however, be easily filled up with earth and refuse.

(*d*) The art of making good roads and footpaths seems to have been lost by the Europeans of the West Coast. They are made with such evident lack of engineering skill as to permit of the rain-water lodging in shallow puddles along their course, or are so badly ditched on each side that water lodges in the gutters as a series of small pools. These are conditions encountered in many parts of the Protectorates, and especially at Lokoja, in Northern Nigeria, as already referred to. Further, after being once constructed, the roads seldom obtain any further attention—the ditches are permitted to partially fill up or become overgrown with weeds. They invariably form excellent breeding places for *Anopheles* : we were always able to find numerous larvae in them.

It is essential that public works and engineering departments in Nigeria should bestow considerably more attention to the construction of properly 'battered' and 'ditched' roads and footpaths, especially in the neighbourhood of the European quarters—both goverment and traders—and thereby remove circumstances which are often a dangerous factor in conditions conducive to ill-health among Europeans in these districts.

To the small hill streams again principles of drainage are applicable. In the hilly regions of Northern and Southern Nigeria hill streams are numerous, gorged and rapid during the wet season, small and sluggish in the dry. During the latter season they afford numerous places for the breeding of *Anopheles*, especially at the points where they are near human habitations. Here and there they swell out into shallow pools from which the water flows very slowly : here larvae are often found, as well as in the sluggish corners and back eddies of the stream. It is evident that a deepening of the stream in parts, or a reconstruction of the channel in others, with occasional attention to see that the channel is clear, would annihilate the undesirable conditions.

(*e*) These conditions have been already described, and, in the places where they were observed by us, it was by no means difficult by judicious drainage to remedy them. In places where these conditions are extensive—reaching over a considerable area of country—drainage might prove very expensive and even impossible.

(*f*) We had no experience of these conditions, and as to whether they really occur we are not certain, having only hearsay evidence of their existence from others who have experienced a dry season on the River Niger. As previously stated, it is very possible for such conditions to arise, but actual observation is necessary to arrive at any decision as to their extent and how they might be treated, if at all.

There is no doubt that thorough surface drainage in very many parts of Nigeria would go a long way towards preventing malarial fever among Europeans,

but it is essential that it be very efficiently and thoroughly carried out; and that the breeding-places should be intelligently searched for.

Further, there are, no doubt, other conditions to which a drainage system could be applied, which have not been included in these remarks, and perhaps others which have not been encountered by us.

II. Destruction of Larvae by the Use of Culicicides

The general use of 'culicicides' as a really efficient method is impracticable. From observations already made, it is clear that the very varying conditions under which *Anopheles* breed do not permit of the general application of any substance which will destroy larvae or prevent their development—applicable either regularly to the surface, as kerosene, tar, etc., or as a substance, such as lime, as has been suggested, which, once introduced, might render puddle, pool, or other collection of water useless for breeding purposes in the future.

Such a duty—in the carrying out of a general practical measure—as the discovery and treatment of *Anopheles* breeding-places, could not be relegated to a native official or number of officials, even under the supervision of a European sanitary officer. The varying and unlimited conditions under which *Anopheles* do and may breed, require the constant attention of one with some special knowledge and previous experience.

In the report of the previous expedition, the use of 'culicicides' was advocated for extensive trial in Sierra Leone, as a result of the observations of the expedition during their visit. And this serves as a striking example of the variability of the conditions at different seasons of the year, for on the visit of the members of the Royal Society's Commission in the dry season, those conditions for which the treatment was suggested had disappeared, and a new set, producing innumerable breeding-places, had arisen for which, in the opinion of the members of the commission, the operations previously suggested were not applicable.

Under certain rare circumstances, apart from any general consideration, the use of 'culicicides' would have to be resorted to as the only method of treatment.

Kerosene regularly applied appears to be the most reliable of a number of proposed culicicidal re-agents: the cheap ideal substance which will have the effect of rendering pools permanently uninhabitable for the larvae is still undiscovered. From a number of experiments performed by us in West Africa with various substances, we are not able to recommend any such substance with the desired properties; further, we deem lime and gas lime, which have been suggested as a possible ideal re-agent, of no value for the purpose.

Our attention having been directed to a statement in the medical journals[3] that in the country in the neighbourhood of Lake Chad, no mosquitoes occur, and

no fever prevails, led us to try the action of the native potash as a 'culicicide.' Native potash is a substance occurring in large quantities as an efflorescence in the country referred to, and to its action of rendering water, in which the potash is dissolved, distasteful to *Anopheles*, is ascribed the freedom of the district from mosquitoes. From our experiments we are unable to infer any decided culicicidal effects (its action was much inferior to that of lime); we are, therefore, inclined to consider the freedom of the district from mosquitoes, if it be really so, as not due to the presence of this substance.

RECOMMENDATIONS

Above we have discussed at some length the practicability of some of the suggestions which have been advanced, either singly or together, as general methods for the prevention of malarial fever in a European community. We have shewn that in a great measure they are unsuitable for adoption on a large scale in Nigeria—partly on account of unreliability and inefficiency—partly because of the enormous expense. But it must not be understood that we wish to discourage in any way the use of the more reasonable of them as measures of some value under certain circumstances, but they are throughout to be considered very subservient to the measures to be suggested; and though by their employment the chances of infection of malarial fever would be more or less diminished, absolute protection against the disease could never be obtained.

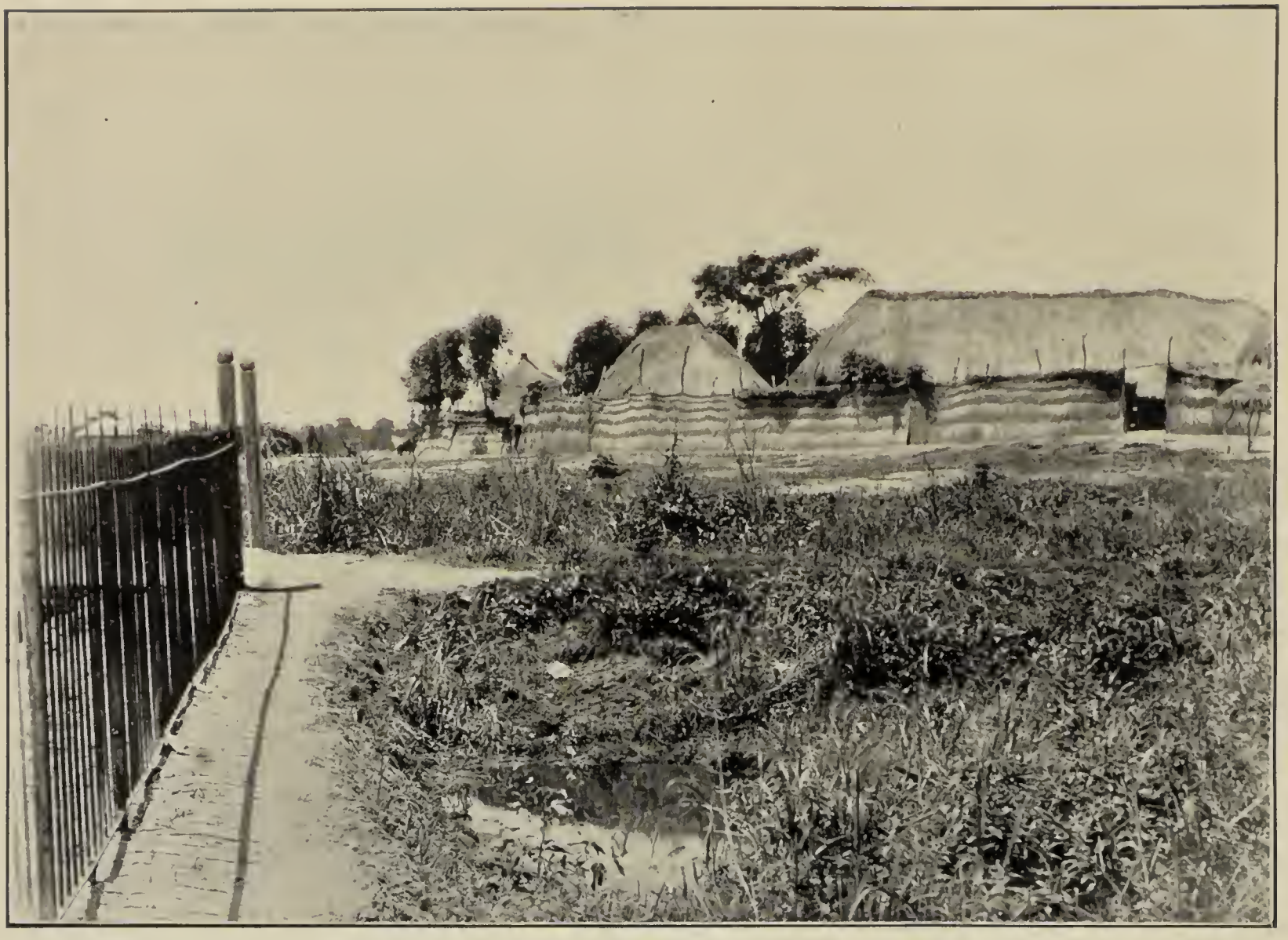
I. Segregation of Europeans at a Distance of about half-a-mile from Natives

The fact that the native children especially constitute a perpetual source of danger to the European, as being naturally the source from which he is infected with the parasites of malarial fever carried from the native by the mosquito of the genus *Anopheles*, suggests very pointedly that the safest and surest plan on the part of the European to guard himself absolutely from any chance of infection would be to live at a distance from the native.

This would have been unnecessary, of course, had the possibility of the suggestion of the use of quinine wholesale among natives been feasible, but the enormous quantity of the drug that would have been required, and the more or less uncivilised condition of West African natives, have been shewn to render the plan impossible.

Similarly, it having been shewn how a total and universal destruction of the insects by any practical means is impossible, and, moreover, since mosquito-proof houses are not at all capable of protecting Europeans from the bites of *Anopheles* at all times of the day and in all the varying circumstances of European life in West Africa—since, indeed, they are impracticable on a large scale—the adoption of the measure of segregation from the native is still more strongly indicated

Segregation of Europeans at a distance from all natives offers itself now as the only measure by which absolute freedom from the disease can be guaranteed, and all the scientific evidence that has been collected respecting the cause of malarial fever and the manner in which infection among Europeans is brought about, markedly



AN *Anopheles* POOL—A PORTION OF A BADLY-CONSTRUCTED DRAIN—AT LOKOJA. THE RAILINGS BOUND THE AREA OF THE NIGER CO.'S FACTORY—THE HUTS OF THE NATIVE TOWN APPROACH ALSO UP TO THE RAILINGS

points to the adoption of segregation principles as the only way in which absolute protection from the disease can be assured.

As has already been pointed out several times, it is almost universally the rule in West Africa to find European houses built round by native quarters, a practice which long experience in India has taught Europeans to carefully avoid. The degree of proximity of the native huts varies in different places. For example, at Old Calabar, many of the factories are almost surrounded, except in front, by native habitations ; similarly at Egwanga, the small native town is built by the side and back of one of the factories, the huts abutting on to the boundary walls. Also at the Niger Company's factory at Lokoja the native houses are very close up to the Company's boundary railings. At other places a small collection of native huts in the vicinity of European quarters serves as a continual source of infection—for example, at Akassa, the barracks of the native soldiers are close to the government vice-consulate, and the small native town near to the quarters of the engineering staff.

It is not essential that the children are of natives of the district, those from other parts of the Coast are equally dangerous. Akassa engineers' quarters may be again mentioned as an example where the engineering artisans, chiefly natives of Lagos, Accra, and Sierra Leone, are housed with their families alongside to the European house. A large proportion of these native children were found by us to contain malarial parasites. Similarly, also, at Asaba, the proximity of the barracks of the Hausa soldiers, who have their wives and children with them, is a dangerous menace to the health of the officers at the Force house.

Examples of the opposite condition of affairs might also be given, for instance, at Old Calabar the Government offices and consulate, vice-consulate, and medical house, are comparatively free from malarial fever, it having been established that the natives shall not build on the European side of the creek separating the two slopes on which the native town and European quarters are built. This creek is at a distance of about half-a-mile from the houses mentioned. The nearer proximity of the barracks of native soldiers to the Force house may possibly account for some cases of fever which occur there.

Further, the factories at Slave Trees, Bakana, and Bugama are at some considerable distance from any natives, who dwell on the opposite side of the river ; the Europeans here enjoy a comparative freedom from fever—although the condition of the surface permits of the production of myriads of *Anopheles* on the spot.

Native servants living in the neighbourhood of Europeans form a source of danger which might in a great measure be prevented. Although they themselves cannot be regarded as an at all common source of infection—indeed only a very rare one—their presence round the European becomes dangerous in two ways. It is the custom to have a number of native servants sleeping in or about the quarters of Europeans.

There is no doubt that natives attract *Anopheles* more than Europeans, and their presence under the circumstances indicated, attracts infected *Anopheles* from other native huts. Although then, a European house may be well segregated, and there may be also no frequenting of the servants' quarters by native children capable of infecting the otherwise harmless *Anopheles* there, yet the native servants form a route along which infected *Anopheles*, from quarters containing children in the neighbourhood, may pass and gain access to Europeans. Further, the native habits permit of the constant frequenting of the native servants' quarters by all sorts of natives from the neighbourhood, and especially of women and children. Some chance of the infection of the otherwise harmless *Anopheles* of the servants' quarters is thus possible. The ideal arrangement for the quarters of native servants is then such as will permit of one or two of them sleeping close to the Europeans—to be within call and to render assistance if necessary—and the others to be relegated to special huts of their own at a distance of about half-a-mile. From our observations in West Africa this could be easily done without occasioning the slightest inconvenience.

Among the trading community, even if properly 'segregated,' there is, perhaps, a further chance of infection among those assistants whose duty requires their presence for a number of hours each day in those 'stores' or 'canteens' of the factory at which the natives of the neighbourhood are retail customers. Here, a number of native women are continually passing in and out, staying often some minutes, with babies on their backs or children at their sides. These latter may be a source from which the otherwise uninfected *Anopheles*, usually so abundant in the shady parts of such warehouses, may become infected, and hence some chance of European infection arise. But, in our opinion, such chances are extremely small—the period of each visit is short, everyone is usually on the move, and, altogether, the prospects of *Anopheles* obtaining a feed of blood from the few native children around, infinitesimally small. Such chances might, however, be negatived by individual precautions against the attacks of the insects by the assistants themselves.

These illustrations of the conditions under which Europeans contract malarial fever in West Africa will also serve for many others than those mentioned. The government administrative commissioner, who visits many places where no Europeans dwell, has to rely on the native huts for his lodgment—and there is usually provided for him one in the midst of the native town. In a few days after his return to headquarters he has an attack of fever contracted during his visit.

Similarly the trading agent, in the interests of his firm, visits a native chief up country (the middleman) and elects to stay one or two days with him at his house in the midst of a crowd of native huts—or may be an assistant at the week end spends his Saturday afternoon and Sunday in a native town, with the result—an attack of fever some days afterwards.

The explorer or traveller visits a native town and is entertained by the chief or other leading man, and passes on ; perhaps reaches a swamp or passes through districts where, it is said, mosquitoes do not occur : here, may be, he has an attack of fever contracted in the native town last visited, and in no way connected with the swamp which is usually blamed ; nor upsetting the mosquito theory because of the supposed absence of the insects in certain districts.

The frequency of malarial fever among missionaries is no doubt explained by the manner in which they are continually exposed to infection in quarters frequented by native children—huts, schools, churches, etc.

The possibilities of the adoption of the method of separation of the living quarters of Europeans from those of the natives in Nigeria are varied.

In new stations at present in course of construction, or about to be constructed, the adoption of such a principle would at once stamp those stations for a healthy prospect. It is in this direction that the greatest amount of benefit is expected to arise. In Northern Nigeria, especially, and in Southern Nigeria, in the near future, when country at present commercially inaccessible to Europeans has been opened up, it cannot be too strongly urged how great is the opportunity for the trial of such an experiment—indeed, it can be hardly called an experiment, since, apart from the consideration of the immediate cause of infection by malarial fever by the agency of the mosquito, it is only common reason that the practice of surrounding oneself with a crowd of uncivilised or semi-civilised natives is an unhealthy principle. Now that malarial fever has been completely traced to this practice, no doubt it will be utterly abandoned.

It seems to us quite as easy now to establish stations with a little care and judgment exercised in the selection of their sites, which shall be healthy, as it was previously, in ignorance, to create unhealthy ones. It must, however, be given as a caution that once established on the improved lines, that is, apart from native quarters, the vicinity of European dwellings must be kept strictly free from the encroachment of native huts—as such is from our observation the usual course of events, the presence of a European immediately attracts the native to settle close beside him—indeed, in some places this is exactly how the present evil conditions have been brought about.

In Nigeria, the stations already established are with two or three exceptions only small. The European community seldom exceeds twelve in number. They consist of administrative, trading, and missionary stations. Many of the government quarters can be segregated with but little difficulty—at Bonny, for example, by removing the nearest native huts and re-arranging the accommodation for the 'Kroo' boys and native servants—and at many places on the river Niger, where the present conditions of living are only temporary, more suitable and healthy sites could easily be acquired. With the trading stations, however, there is more difficulty since they

consist of large warehouses and stores erected at considerable expense. Mission stations also generally present similar undesirable conditions.

In the larger towns, such as Old Calabar, the difficulties become almost unsurmountable. Removal of European business premises is entirely out of the question, but the exigencies of trade and administrative work would permit of the occupation of healthier sites during the evening and night, as has been suggested by the medical and public works officers of that town.

But in all such cases which are difficult to deal with, probably a great deal might be done to remove the natives from their present positions near factories. We do not suggest as feasible a total destruction of such native huts at once, but we see no objection why such control over the neighbouring land should not be gradually acquired, so as to bring about the removal of these native huts, and thus remove a dangerous menace to health. These native huts are of but little worth, and are easy to construct in a very short time. It will become a subject for government policy to enable Europeans to proceed in this direction, involving, perhaps, slight compensation to the natives affected, and it is trusted that, after consideration of all the advantages and the economy which would accrue upon the prevention of malarial fever among a community of Europeans, both engaged in their employ and in trade, the government will in the near future adopt such a policy as will help and render easy the adoption of the principle of segregation.

II. The Surface Drainage of Areas round European Quarters

It has already been pointed out that one way in which infected *Anopheles* may filter through from native childrens' quarters to Europeans at a distance of even half-a-mile from them is by means of the quarters of native servants lodged at different points in the intermediate space.

Yet another way is by means of such collections of water as might serve for breeding places. It is easy to perceive that a number of infected *Anopheles* from childrens' quarters in search of water on which to lay their eggs, might have to choose a collection near to European quarters and from it fly to the nearest European habitation.

Complete drainage of the surface and the destruction of all such collections of water as might serve as breeding-places for *Anopheles* must then necessarily accompany the adoption of the measure of 'segregation,' if the community is to continue completely protected from malarial fever attacks, and it is our opinion that such a combination of the practice of segregation and efficient surface drainage would be followed by complete freedom from the disease among Europeans. The details of the various conditions under which *Anopheles* have been observed to breed in Nigeria

PORTION OF A CULTIVATED AREA AT LOKOJA, SHOWING BUTTS AND FURROWS,
IN THE LATTER OF WHICH *Anopheles* PUDDLES OFTEN OCCUR

have already been given, and it only remains to once again emphasise that an efficiently and intelligently executed system of extirpation is necessary.

Under circumstances where at present 'segregation' is impossible, the destruction of breeding-places of *Anopheles* by drainage and other means already referred to would prevent the multiplication of the insect to some extent, and thus render the chances of infection much less. But it is to be remembered that so long as the mosquito is able to obtain feeds of blood she can live for very long periods, during which she is continually on the watch for a suitable opportunity to deposit her eggs, and that the most unlikely and unusual sites would be utilised for that purpose. This shews the necessity for a thorough destruction of water collections and of the great difficulty of eradicating all, especially in native surroundings.

But the creating and maintaining of breeding-places by such means as the construction of bad roads and footpaths, wells, unnecessarily uncovered, and so on, is inviting disaster. Half-a-mile has been fixed as the distance which should separate European and native quarters from a consideration of the habits of *Anopheles*. There is some considerable evidence for the assertion that these insects do not fly far and that they spend their lives very close to the spot at which they were hatched from larvae. It is extremely rare also that a breeding place for *Anopheles* is found at a greater distance than half-a-mile from the dwellings of man or from spots frequented by man.

Objections raised against the principle of segregation. The only objections which we have become cognisant of, have arisen chiefly among the West African merchants. Excluding any reference to expense, the chief objection has been that such a segregation as that suggested would seriously affect trade. It must be remembered that a distance of half-a-mile only has been fixed. We are totally unable to perceive how in any part of Nigeria such a procedure could in any way affect the trade at any of the factories we have visited. We urge that the principal trade is done, not with natives in the immediate neighbourhood of a factory, but with influential chiefs and middlemen, who generally dwell some distance up the rivers. The small retail trade done with natives living close to factories would be quite uninfluenced if they were removed to a distance of half-a-mile. In fact, some factories are situated at more than half-a-mile from any native town, and do excellent trade—to walk such a distance and carry back their wares is a mere nothing to a native.

The only other objection heard of refers to social conditions. It must have arisen from a misunderstanding of what was suggested, probably from the roughest idea of what 'segregation' might mean,—a wholesale removal of Europeans from among the natives, who were to be regarded as unfit for any intercourse or dealing. Such aggravated ideas are evidently absurd, and it is not clear how the adoption of the principle of 'segregation,' as described above, can in any way influence the present social relations between European and native.

In concluding these recommendations for the prevention of malarial fever, it has been considered necessary to more particularly point out in what way they can be adopted in individual cases. Presuming, beforehand, that attention be paid in every case to precautions exercisable by every individual—namely, the careful use of mosquito curtains and of suitable clothing to prevent the bites of mosquitoes, as well as the use of mosquito-proof houses in certain circumstances, and the intelligent and regular administration of quinine, a certain amount of care might be exercised by some individuals who meet unusual circumstances.

We have stated that, for a community of Europeans, segregation and drainage are to be relied upon, while the use of mosquito-proof houses, mosquito curtains, quinine, and other measures are subservient to these, and more applicable by individuals ; also that, in a segregated community, the servants must also be properly placed.

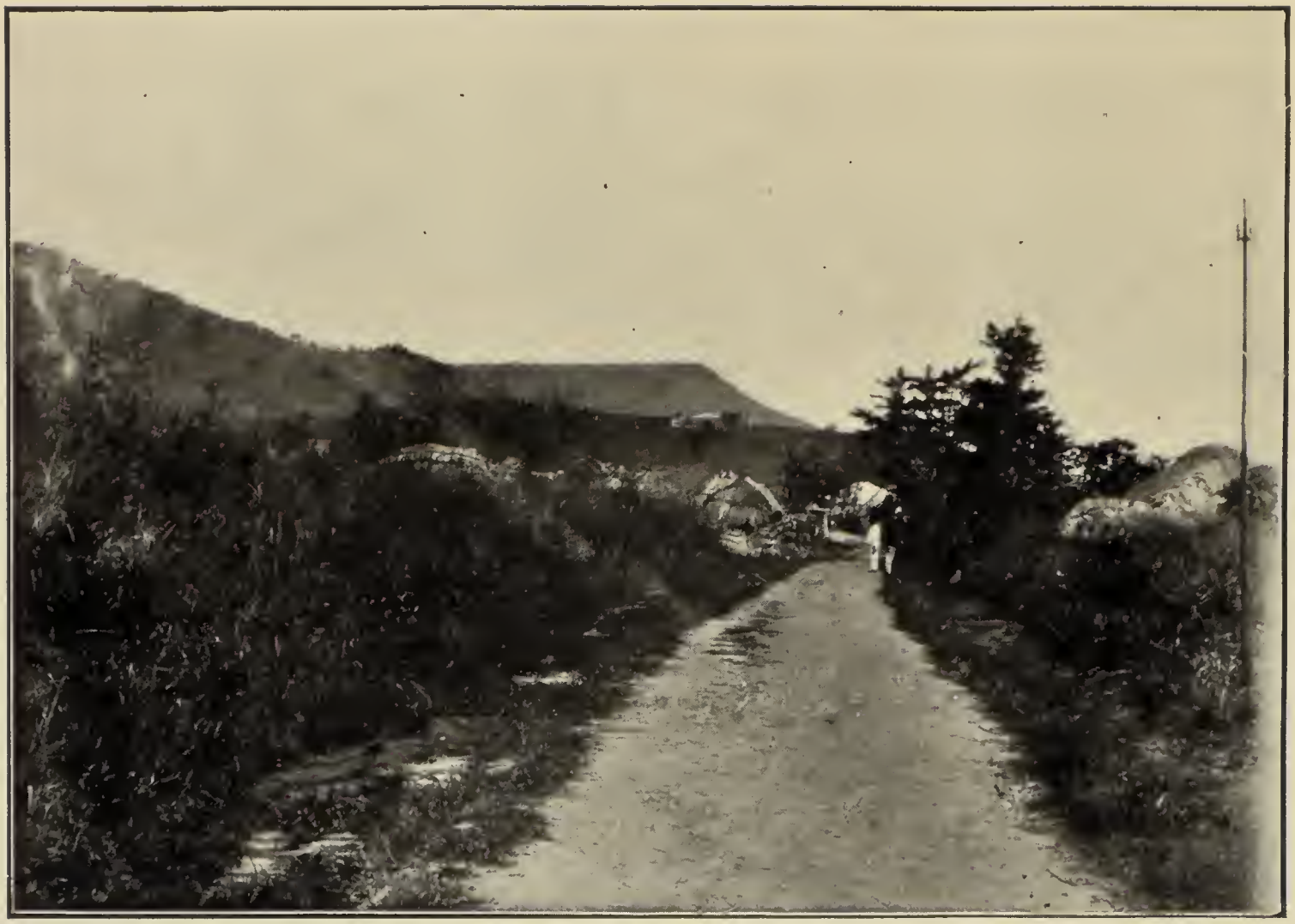
For military officers in permanent camp, it is advised that particular care be bestowed on the disposition of the huts of the native soldiers—which should be placed at a distance of half-a-mile from officers' quarters, and those of soldiers with their families at a still greater distance, if possible. In temporary camp, choice of a site on 'segregation' principles is advised, that is, away from the native huts.

Commissioners and other government officials, as well as travellers and explorers, should avoid sleeping in native huts. It is advisable to pitch tents for themselves and their servants and followers for sleeping purposes away from native towns and villages.

Agents and assistants at trading factories will be careful in the choice of sites for new stations, and will as far as possible re-arrange their compounds so as to place their servants and labourers at as great a distance as the extent of their areas permit and, moreover, to ensure that no collection of surface water on the area can exist.

Similar advice might be given to those Europeans engaged at mission stations.

With those engaged on surveying parties or on the construction of railways, the exercise of the principle of segregation is very easy. It is again the custom at each little station to find Europeans surrounded by natives of all sorts and ages. It is evident that at such places where absolute control over the disposition of all houses, tents, and huts is easy, to so place all such native followers and labourers as not to constitute a danger, presents no difficulty whatever. The construction of railways in West Africa has always been associated with many cases of malarial fever, which were formerly attributed to 'the turning over of the soil.' Now they are easily explained by the formation of numerous breeding-places for *Anopheles* created by turning over the soil in the construction of the railway—thus supplying the carrier of the disease ; and the practise of permitting labourers and servants with their families to live close to European quarters—thus supplying the



THE ROAD LEADING INTO THE NATIVE TOWN OF LOKOJA.

ALONG ITS SIDES ARE DITCHES FORMING A STRING OF PUDDLES CONTAINING *Anopheles* LARVAE.
TO THE LEFT, BEYOND THE PORTION TAKEN IN THE PHOTOGRAPH, A BANK AND
OTHER EUROPEAN QUARTERS ARE IN COURSE OF CONSTRUCTION.

source of the infection. Such undertakings ought to continue absolutely free from malarial fever, if the above precautions were practised.

For the prevention of malarial fever among European crews on board ship, the regular administration of quinine, according to the suggestions of Professor Koch, seems to us very feasible. We have shown how *Anopheles* come on board and remain often a considerable time. There is also a possibility of their becoming infected from the few children which are carried from port to port on the West Coast of Africa. The chief source of their infection is, of course, the children of the native towns opposite which the vessels anchor. Professor Koch suggests that the administration of quinine be undertaken in the following manner, and there is no reason why this should not be regularly carried out by the ships' doctors, after the outward-bound vessels have reached the coast. Fifteen grains of quinine are to be administered on each of two successive days, preferably in the early morning ; then a period of seven days without the drug is allowed, and the administration of fifteen grains again continued daily for two days, and then another seven days' interval, and so on, for the whole voyage.

APPENDIX

AN UNCLASSIFIED WEST AFRICAN FEVER

In the *British Medical Journal* of January 26, 1901, S. W. Thompstone, F.R.C.S. and R. A. Bennett, M.B., M.R.C.S., district medical officers at Old Calabar, gave a preliminary note on an unclassified type of West African fever—to which they proposed to give the name 'hyperpyrexial fever.'

The cases occurred during the stay of the members of the expedition at Old Calabar, and we were able to watch the course of the disease in both cases.

By the kind permission of Drs. Thompstone and Bennett we are allowed to reproduce the short account of their cases here—and we are indebted to Dr. Shekleton of Bonny for the earlier part of the temperature chart of the second case, which occurred at Bonny. Because of lack of hospital accommodation and the impossibility of affording such constant attention as such a case demanded, this patient was shipped to Old Calabar and treated at the European hospital there.

We now give the remarks of the authors of the communications to the *British Medical Journal.*

'Clinical Features of Hyperpyrexial Fever

This fever is generally ushered in by a slight rise of temperature followed by profuse perspiration and a fall in the temperature to about 99° F. After a period of apyrexia of perhaps twenty-four hours' duration the temperature begins again to rise, slowly at first, but when 105° is passed with alarming rapidity, one degree in ten minutes having been frequently observed, and it may reach 107° on the second day. For fourteen or even for thirty days subsequently there is absolutely no tendency for it to fall. The skin acts either very slightly or not at all, and all antipyretic drugs fail.

The tongue is at first furred on the dorsum and red at the edges and tip ; late in the disease it becomes dry and shrivelled. There is no enlargement of the liver or spleen. The urine is of normal character and abundant ; the bowels are regular or inclined to looseness. The conjunctivae are injected and the pupils contracted. The mind remains remarkably clear in most cases, except when the temperature is at its highest, but constant symptoms in the early days are great anxiety and restlessness.

With regard to the examination of the blood, no plasmodia nor pigmented leucocytes have ever been discovered, but in two of the later cases it was noticed that the blood tended to coagulate the moment it was exposed to the air, so that it was only with great difficulty that satisfactory films could be obtained.

Typical Examples of the Disease

Case I. This patient had been on the Coast for about five months, and had had no fever until the present attack. During the last month he had lived in a tent at a quarry some

twenty miles up the Akwayafe river, and, feeling ill four days before admission, got into a canoe and found his way down to the mouth of the river, where he was picked up by a launch and brought to the hospital. On admission, his temperature was only 99·6° F., and he was apparently going on satisfactorily when, as in the previous cases, his temperature began slowly to creep up the beginning of a constant tendency towards hyperpyrexia. He was treated by baths, as will be subsequently described. After his fourth bath he was put into a cold pack, which was changed every hour for four days. The temperature then steadied, and eventually he left for home practically well.

Case II. This patient was sent from an out-station on the fourteenth day of his illness, and was still under treatment when the record was made. So marked was the tendency to hyperpyrexia that on two occasions no fewer than two cold baths were necessary in the twenty-four hours, and it was not until the twenty-second day of the disease that it was possible to substitute the continuous pack for the cold bath. From that time until now the temperature has averaged 102°. The patient lies helpless in bed, occasionally showing some glimmering of intelligence, but for the most part remaining unconscious of his surroundings, taking nourishment well, but passing urine and faeces under him. This condition, as far as we could tell, may continue indefinitely, The temperature shows no tendency to assume alarming proportions, and the heart and lungs are acting well.

Charts

Treatment of the Condition

This may be summed up in one word—baths. The patient is put into a cold bath, and his temperature brought down to 100° or 99°. He sleeps for about an hour, and then feels fairly comfortable, but the temperature at once begins to creep up again, and in eighteen or twenty-four hours it is back at 106°, or at the point at which it is considered advisable to check it. Quinine and other drugs have been systematically tried without influencing the course of the disease ; the coal-tar antipyretics are absolutely useless. Cold sponging and packs are incapable by themselves of reducing the temperature, although in a recent case which recovered it was found that by reducing the temperature by means of the cold bath to 101° or 102° it was possible to keep it there by means of cold packs renewed at hourly intervals.

Progress of the Cases

It has been observed that, if the patient is to recover at all, some change for the better is to be looked for about the end of the third week. The temperature, which up to this time would constantly rise at once after the bath, might remain at 102° or 103 for several hours, and perhaps in the course of the next week two or more days might pass without the necessity for a bath. Convalescence is gradual, and it may be six weeks after the onset of the fever before the temperature finally assumes its normal course. On the other hand, in 50 per cent. of the cases which have come under observation a fatal issue has occurred.'

Several examinations of the blood of both cases were made by Drs. Thompstone and Bennett and by ourselves, but neither malarial parasites nor pigmented leucocytes were observed. Several times on the day of the arrival of the second case at Old Calabar, and on many subsequent occasions, we carefully examined the blood both by fresh and stained specimens.

Dr. Shekleton, of Bonny, states that he found the ring forms of aestivo-autumnal fever in the blood of his patient on the first day of the attack, but none subsequently.

On the sixteenth day of the disease (two days after arrival at Old Calabar) an estimation of the number of corpuscles gave 4,384,000 red, and 15,000 white per c.m., by the Thomas Zeiss apparatus ; and the haemoglobin was estimated at 90 per cent. Three attempts to obtain micro-organismal cultivations from the blood on agar-agar and serum failed. A peculiar tendency of the blood to rapid coagulation was noted. Dr. Thompstone states he has never been able to find malarial parasites in other cases of this disease which have come under his observation. It is to be pointed out that these cases occur during the dry season, at a time when the number of cases of malarial fever is smallest. There is often a history of exposure to the sun's heat, rough conditions of life, and hard work.

The onset, symptoms, and course of the disease are quite atypical of malarial fever : there is absence of rigors, shivering, vomiting, severe headache, etc., etc. ; the liver and spleen are not enlarged nor tender : consciousness is preserved often to the end. The disease may last about a week, or be extended to three or four. There is a continual tendency to hyperpyrexia, only checked by cold baths, by which means the temperature is easily reduced, but it gradually creeps up again directly the cold applications are removed. After a hyperpyrexial stage of one to three weeks' duration, there is always a very long period during which the temperature continues above the normal—a very extended lysis—varying during the day not more than a degree, and falling gradually degree by degree every four or five days.

Drugs, including quinine and phenacetin, seem to have no effect on the course of the disease.

Lung trouble caused the death of the second case on the evening of the day previous to our departure from Old Calabar, and, through the kindness of Dr. Thompstone, we were able to hold a post-mortem examination on the case two hours after death, the details of which we are able to record :—

No rigor mortis : but little wasting : no jaundice : small clean sore over sacrum : no trace of syphilis.

Abdomen—No fluid in peritoneal cavity : serous membrane appeared normal, excepting two small patches, one of old, one of recent perihepatitis, on the upper surface of the right lobe of the liver.

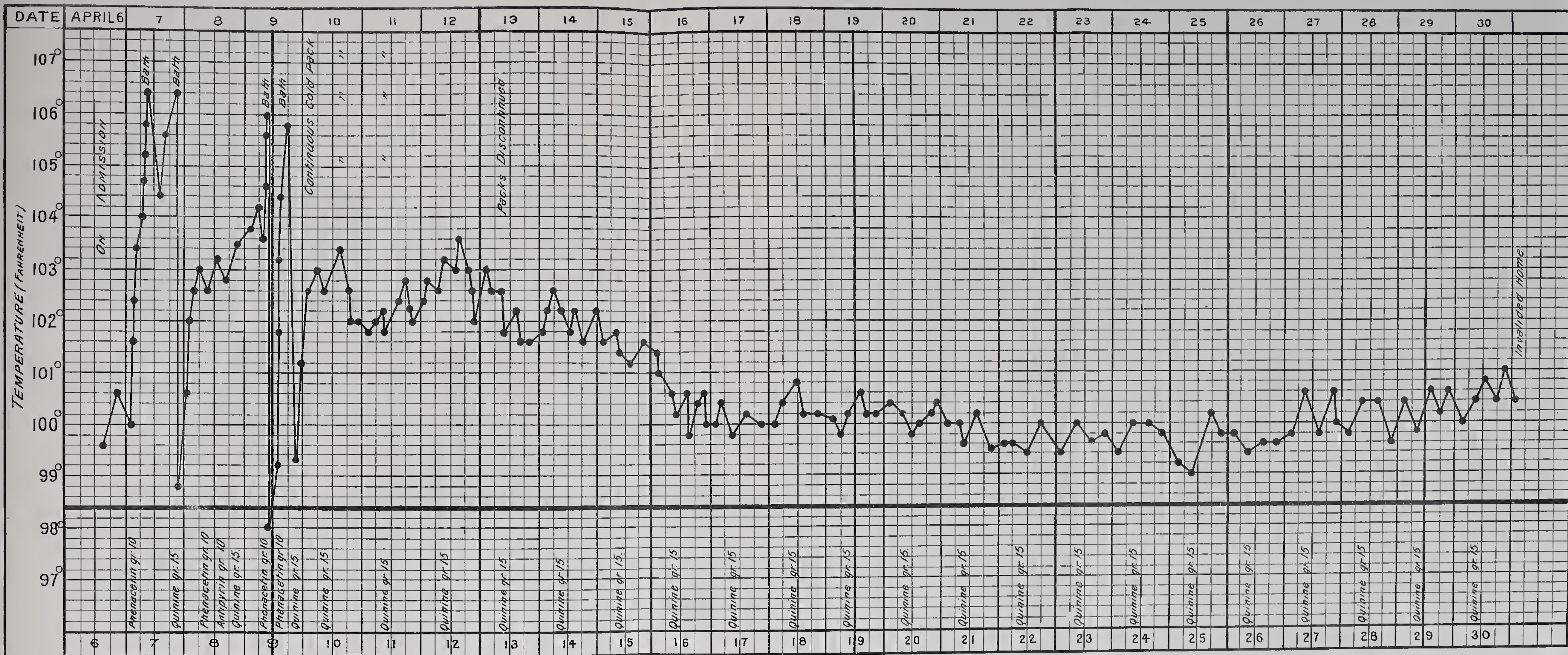
Pancreas—Somewhat large and firm.

Spleen— Did not extend below the costal margin—about the size of one's hand ; firm in texture—externally of slaty appearance ; on section, firm, dark in colour.

Liver—Two small patches of perihepatitis on upper surface of right lobe. Somewhat enlarged and firm ; on section, firm and dark in colour : no sign of fatty degeneration nor cloudy swelling.

Kidneys—Large—capsule stripped uniformly, somewhat adherent all over. On section, red and granular—'large red granular kidney.'

Stomach—Contained a quantity of gruesome, blackish-brown stained mucus in flakes between the rugae. Mucous membrane pale, shewed very small petechial areas to which the blackish shreds were attached.



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TEMPERATURE (FAHRENHEIT)
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97°
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Bath
Bath
Bath
Bath
Continuous Cold Pack
Packs Discontinued
Invalided Home
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Phenacetin gr. 10
Antipyrin gr. 10
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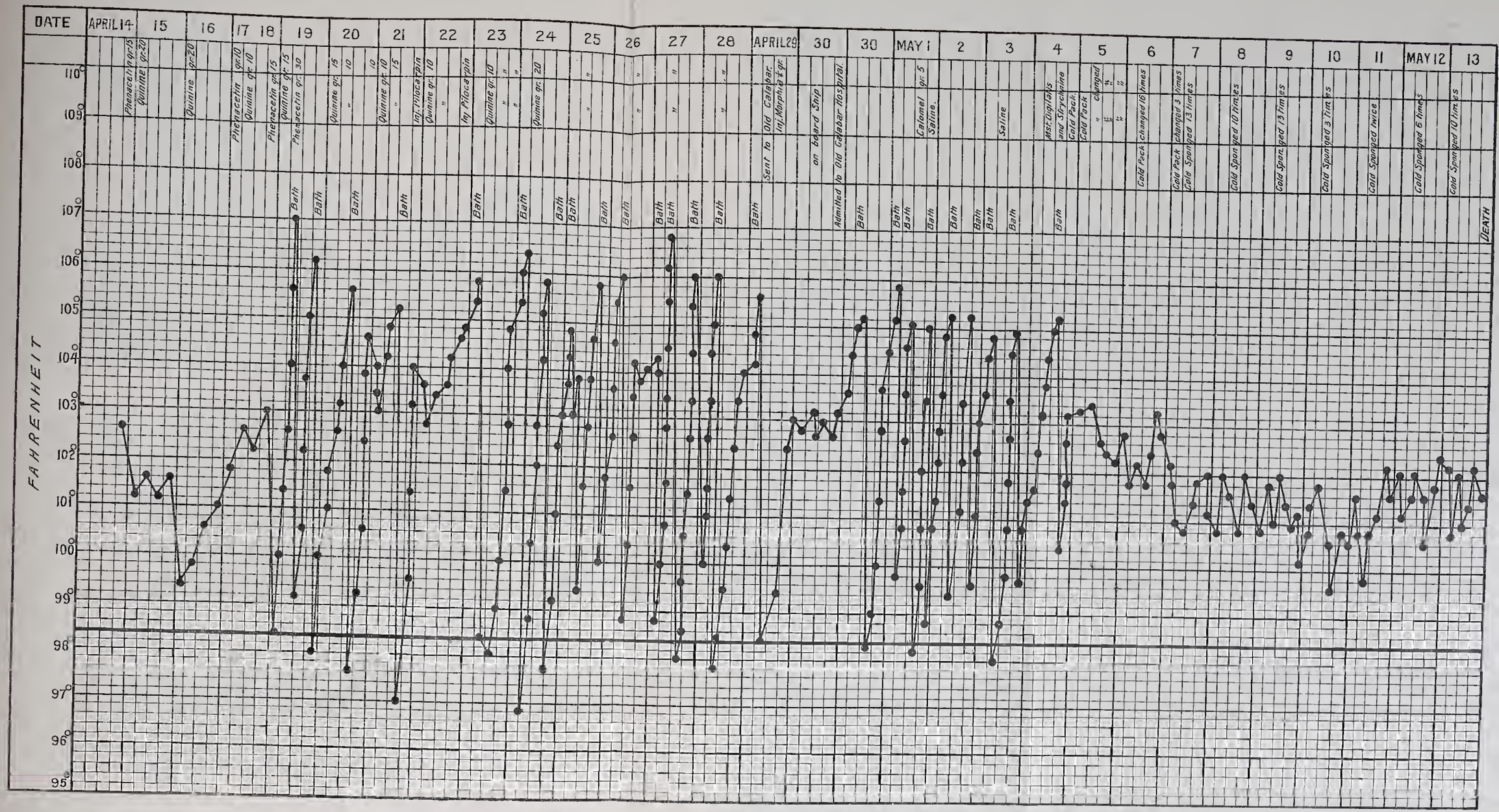
Quinine gr. 15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Inj. Pilocarpin
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Inj. Morphia ½ gr.
on board Ship
Admitted to Old Calabar Hospital.
Calomel gr.5
Saline.
Saline
Mist. Digitalis
and Strychnine
Cold Pack
Cold Pack
" changed
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"
Cold Pack changed 16 times
Cold Pack changed 3 times
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Cold Sponged 3 times
Cold Sponged twice
Cold Sponged 6 times
Cold Sponged 10 times
DEATH
Bath

Duodenum and Small Intestine were stained a dull, greyish-brown colour. About nine inches from duodenum to a few inches from the coecum, the gut containing frothy, blackish-brown, mucous material staining the mucous membrane. No petechial nor haemorrhagic spots. Mucous membrane otherwise normal.

Coecum and large Intestine appeared normal.

Suprarenals and Bladder—normal.

Thorax—No pleuritic fluid—slight old adhesion at the base of the right lung. No periodical fluid.

Heart—Left ventricular wall hypertrophied. Cardiac muscle firm. Valves healthy. Slight early atheroma of the aorta just above the valves.

Lungs—Some old pigmented fibroid patches at both apices. Patch of old pleuritis at right base adhering to the diaphragm. Bronchi contained a quantity of yellowish muco-pus. This condition extended down to the small bronchioles. On section of the lung, muco-pus welled from numerous points. No broncho-pneumonia. No hypostatic congestion.

Oesophagus—Normal.

Trachea—Contained a little muco-pus.

Epiglottis—Two very small ulcers at the base size of pinhead.

Pharynx and Thryroid Gland—Normal.

Brain—Rather wet and oedematous, firm, otherwise appeared normal; numerous small pachionian bodies.

Morbid Histology

Liver—Sections of the liver present very little pathological change. There is a slight increase of fibrous tissue around the portal canals, with a slight thickening of 'Glysson's' capsule. Slight congestion of the hepatic zone. The liver cells are sharply defined—the nucleus staining well with Haematein, the cell protoplasm shews a very slightly granular appearance. Slight fatty infiltration occurs in the portal zones of some of the liver lobules. Marked yellow pigmentary deposit is observed in the liver cells throughout the whole lobule. No recent malarial pigment can be made out in the capillary endothelial cells, and traces of old pigment are only very occasionally seen. The liver cells throughout the lobules give a marked reaction of iron with pure haematoxylin, and with potassium ferrocyanide and hydrochloric acid.

Spleen—Sections shew an increase of fibrous tissue. The trabeculae are thickened and the splenic pulp appears overgrown with fibrous tissue. The small arteries of the Malpighian corpuscles, which are inconspicuous, are greatly thickened both throughout their internal and external coats. The splenic capsule is thickened. Malarial pigment only occurs at very rare intervals throughout the sections. With ferrocyanide of potash and hydrochloric acid, and also with pure haematoxylin no very marked iron reaction is brought out. Masses of haematoidin pigment were scattered throughout the sections.

Kidney—Sections again shew fibroid changes in the thickened capsule of the organ, with a tendency to spread into the kidney substance. Some of Bowman's capsules are thickened—and there is some thickening of the arteries. The renal cells of the tubules are well defined—nuclei stain well—the protoplasm has a slightly granular appearance, and in places there is a slight epithelial desquamation, with a granular deposit in the tubules. There is some congestion of the stellate veins and vessels of the boundary layer. No pigment present.

Lung—Sections shew a condition of marked emphysema. Round some of the bronchi the alveoli are filled with a catarrhal exudation, and a few golden corpuscles are present. The bronchi shew catarrhal inflammatory changes.

Brain—In sections of the cerebral cortex, and of the corpus striatum,* no pathological changes can at present be made out. No malarial pigment is present.

The interesting features to be noted in the results of this examination are the absence of recent malarial pigment from the positions in which it is generally found in cases of malarial fever—and secondly, the absence of cloudy swelling of the parenchymatous epithelium of the organs, and of marked fatty degeneration such as one would naturally have expected as a result of a period of some four weeks' high temperature. It must be stated that the patient had been several years on the West Coast of Africa, and had had several attacks of malarial fever, thus accounting for the presence of a little old pigment.

The absence of cloudy swelling and fatty degeneration changes in the organs points not only to the non-malarial nature of the disease but, we take it, also that a 'toxic' substance produced in the course of a specific infective disease was also absent. It has been suggested that the characteristics of this disease—the peculiar absence of local symptoms, the manner in which the temperature is uninfluenced by drugs, but easily affected by cold applications, and the long period through which it gradually becomes normal, as well as the conditions found on pathological examination—might be all explained by some profound disturbance in the process of heat regulation.

In this connection it may be pointed out, on the West Coast of Africa a temperature of about 130° F. and an atmospheric humidity of between 90 and 100 per cent. are often associated, and that these conditions have considerable influence on the health of Europeans in those parts—accounting for some few of those cases treated as malarial fever cases. From our own observations such cases occur, from which the typical signs and symptoms of malarial fever are absent. It has been noted that no cases of insolation, siriasis, sunstroke, sun or heat fever are found mentioned in the medical reports of Southern Nigeria. It was our experience at Old Calabar that the climatic conditions often produced a slight rise of temperature, and for experimental purposes we occasionally undertook rather severe exercise, such as hard walking (provided with sun helmet or shade) in the open, and almost invariably noted a rise of temperature after an hour or so, although perspiring profusely at the time. Temperatures reaching up to 102·2° F. were observed—normal being reached in the course of a few hours. It is easy to imagine that an exaggeration of such conditions, together with a constitutional condition in which from any cause the dissipation of the heat of the body does not balance the production might, perhaps, lead to such an overthrow of the process of heat regulation as to occasion conditions similar to those of the so-called 'hyperpyrexial' fever cases described.

*Further investigations in the pathological histology of the corpus striatum in this case are being undertaken.

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14 „ „ „ „ „ „ „ „ Page 37

CHAPTER III.

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2 *Reports to the Malaria Committee of the Royal Society.* Aug. 15, 1900

3 *Reports to the Malaria Committee of the Royal Society.* (Third Series.) Page 5

CHAPTER V.

1 MANSON. *British Medical Journal*, March 17, 1900

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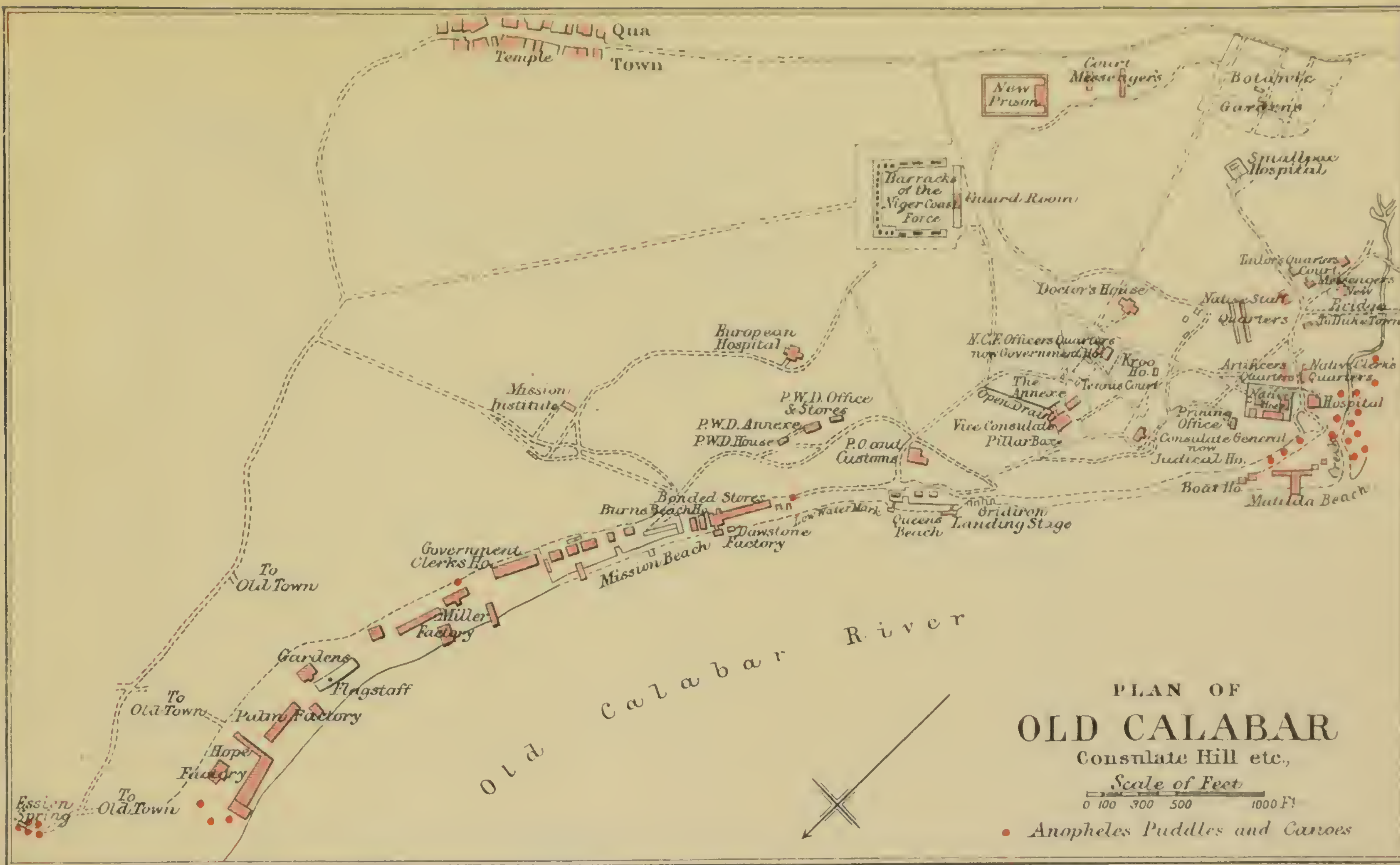
3 *British Medical Journal*, March 31, 1900

The accompanying plans of the Consulate Hill, Old Calabar, and of part of Duke Town, shew the positions of the breeding-places (canoes, puddles, and spring) of *Anopheles*. We are indebted to H. M. Bradford, Esq., Acting Chief Officer of the Public Works Department for these, the only available plans. The breeding-places are marked in red, and it is to be noted how they are most abundant generally in the neighbourhood of those factories which are more or less surrounded by native huts. The plan of part of Duke Town also shews how efforts are being made to relieve the crowded and badly arranged condition of the native town by the construction of wide roads and streets.

DONALD FRASER, PRINTER TO THE UNIVERSITY PRESS OF LIVERPOOL


PLAN OF
OLD CALABAR
Consulate Hill etc.,
Scale of Feet
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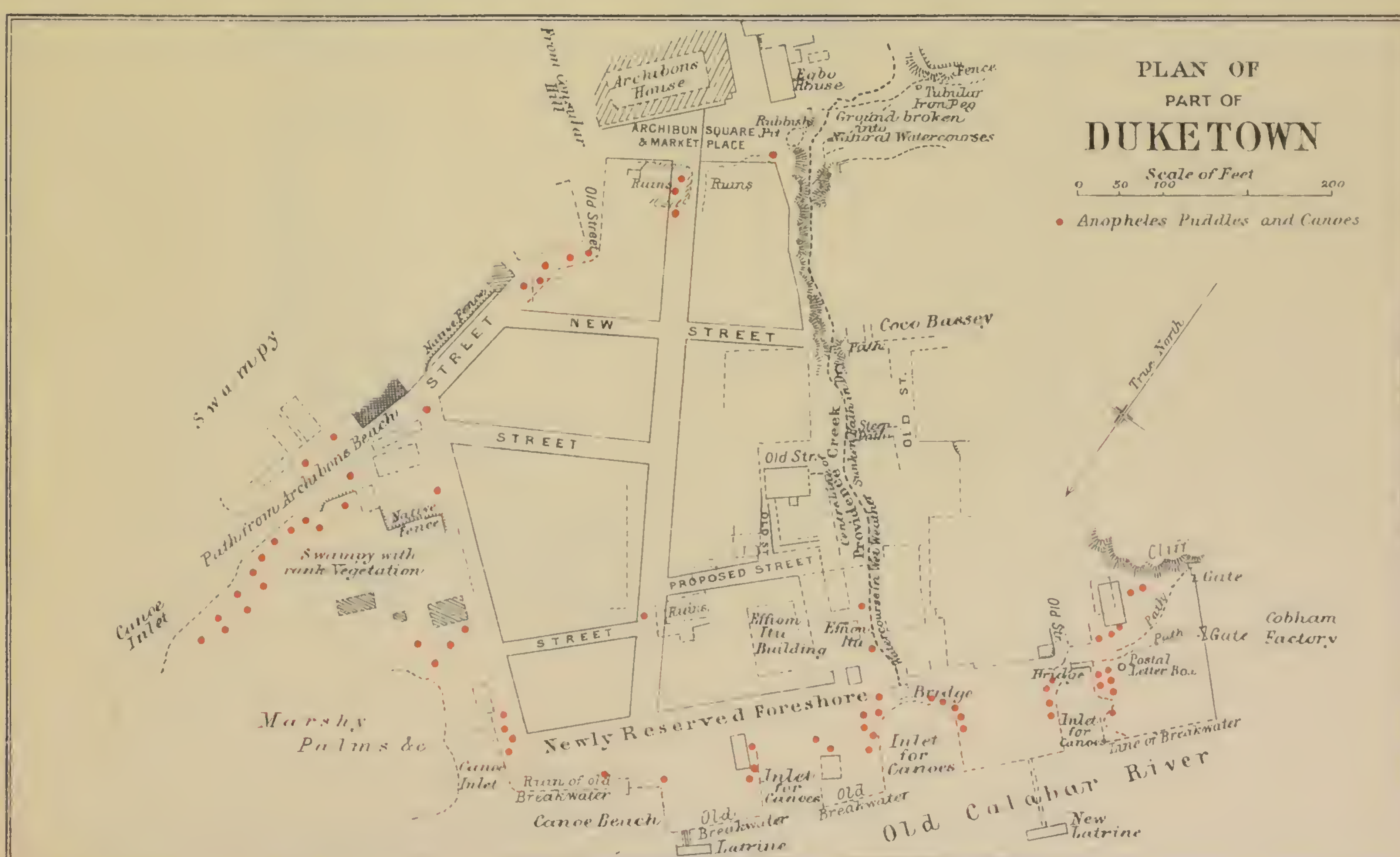
Anopheles Puddles and Canoes
Qua
Temple
Town
New Prison
Court Messengers
Botanic Gardens
Smallpox Hospital
Barracks of the Niger Coast Force
Guard Room
Doctor's House
Native Staff Quarters
N.C.F. Officers Quarters now Government Hotel
Kroo Ho.
The Annexe
Open Drain
Tennis Court
Artificers Quarters
Native Clerks Quarters
Hospital
Printing Office
Consulate General now Judicial Ho.
Vice Consulate
Pillar Box
Boat Ho
Matilda Beach
European Hospital
Mission Institute
P.W.D. Office & Stores
P.W.D. Annexe
P.W.D. House
P.O. and Customs
Bonded Stores
Burns Beach Ho
Low Water Mark
Queens Beach
Gridiron Landing Stage
Dawstone Factory
Government Clerks Ho.
Mission Beach
Miller Factory
To Old Town
Gardens
Flagstaff
Palm Factory
Hope Factory
Essien Spring
Old Calabar River

G. Philip & Son


PLAN OF
PART OF
DUKETOWN
Scale of Feet
0 50 100 200
Anopheles Puddles and Canoes
Archibons House
Egbo House
ARCHIBUN SQUARE & MARKET PLACE
Rubbish Pit
Fence
Tubular Iron Peg
Ground broken into Natural Watercourses
From Consular Hill
Ruins
Old Street
NEW STREET
Coco Bassey
Path
STREET
Native Fence
Swampy
Archibons Beach
Path from Archibons Beach
Swampy with rank Vegetation
Canoe Inlet
Old Str.
Creek
OLD ST.
Step Path
PROPOSED STREET
Effiom Ita Building
Effiom Ita
Cliff
Gate
Cobham Factory
Postal Letter Box
Bridge
Inlet for Canoes
Line of Breakwater
Marshy Palms &c
Newly Reserved Foreshore
Ruin of old Breakwater
Canoe Beach
Old Breakwater
Latrine
New Latrine
Old Calabar River
True North

G. Philip & Son.

MAP OF THE

LOWER NIGER

to accompany

THE REPORT OF THE

MALARIA EXPEDITION

Scale 1:2,000,000

Places visited underlined in Red.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

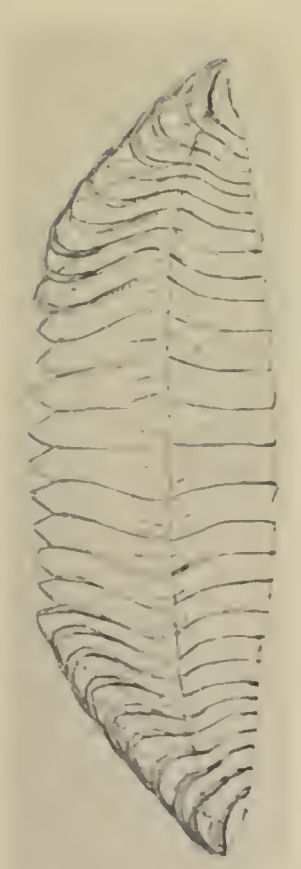


FIG. 6

FIG. 1. *Anopheles* ovum—superior surface
FIG. 2. „ „ —inferior „
FIG. 3. „ „ —side view
FIG. 4. *Culex* ovum
FIG. 5. *Anopheles* ovum—empty egg case
FIG 6. The 'float'—upper surface
FIG. 7 „ „ —lower „

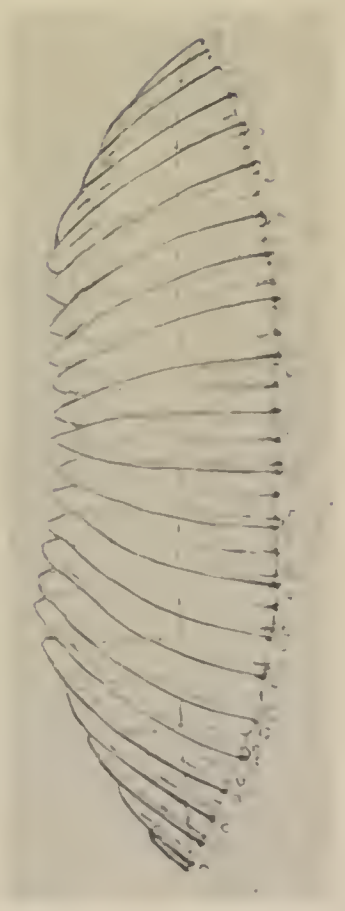


FIG. 7

FIG. 1. The characteristic pattern in which *Anopheles* ova are deposited on the surface of water

FIG. 2. Showing larvae in several stages of their escape from the ova